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NINETEENTH ANNUAL REPORT

OF THE

STATE BOARD OF HEALTH

OF

MASSACHUSETTS.

BOSTON:
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1888.

MEMBERS OF THE BOARD.

1887–1888.

HENRY P. WALCOTT, M.D., *Chairman*, . .	OF CAMBRIDGE.
ELIJAH U. JONES, M.D., ...	OF TAUNTON.
JULIUS H. APPLETON, ...	OF SPRINGFIELD.
THORNTON K. LOTHROP, ...	OF BEVERLY.
FRANK W. DRAPER, M.D., ...	OF BOSTON.
HIRAM F. MILLS, C.E., ...	OF LAWRENCE.
THEODORE C. BATES, ...	OF WORCESTER.

Secretary.

SAMUEL W. ABBOTT, M.D.

Engineer.

F. P. STEARNS, C.E.

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Office of State Board of Health,
13 Beacon Street, Boston, Jan. 9, 1888.

To His Excellency Oliver Ames, *Governor*.

Sir: — I have the honor to present herewith the report of the State Board of Health of Massachusetts for the year ending Sept. 30, 1887, in compliance with the provisions of chapter 101 of the Acts of 1886.

Respectfully,

SAM'L W. ABBOTT,

Secretary.

GENERAL REPORT.

The following report of the State Board of Health contains the results of inquiries conducted by the Board during the year ending Sept. 30, 1887, under the provisions of the organic act creating the Board, and under the provisions of certain special acts, up to a later date. The report embraces the following topics: —

GENERAL WORK OF THE BOARD.

REPORT OF THE TRANSACTIONS OF THE BOARD UNDER THE PROVISIONS OF CHAPTER 274 OF THE ACTS OF 1886, FOR THE PROTECTION OF THE PURITY OF INLAND WATERS.

REPORT ON FOOD AND DRUG INSPECTION REQUIRED BY CHAPTER 289, SECTION 2, OF THE ACTS OF 1884.

REPORT ON THE SUBJECT OF OLEOMARGARINE, UNDER THE AUTHORITY OF AN ORDER OF THE LEGISLATURE OF 1887, DATED JUNE 3, 1887.

SUMMARY OF WEEKLY MORTALITY REPORTS.

VENTILATION AND HEATING OF SMALL SCHOOLS.

The Board, as reconstituted under the authority of chapter 101 of the Acts of 1886, is composed of the following members: —

HENRY P. WALCOTT,
ELIJAH U. JONES,
THORNTON K. LOTHROP,
FRANK W. DRAPER,
JULIUS H. APPLETON,
HIRAM F. MILLS,
THEODORE C. BATES.

The term of office of JAMES WHITE expired in June, 1887, and he having declined a reappointment, THEODORE C. BATES was appointed to fill the vacancy.

At the annual meeting held in June, 1887, the following officers were chosen: —

Chairman, . . .	Henry P. Walcott.
Secretary, . . .	Samuel W. Abbott.

Under the provisions of a special act (chapter 274 of the Acts of 1886), Frederic P. Stearns was also reappointed as the Engineer of the Board, and Joseph P. Davis as Consulting Engineer.

The following are the by-laws adopted by the Board: —

1. The Board shall, on the first Tuesday in June in each year, elect by ballot a chairman and a secretary, who shall each hold office for one year and until his successor shall have been chosen. In the absence or disability of the chairman or secretary, a chairman or secretary *pro tempore* may be chosen, as the Board may determine.

2. Regular meetings of the Board shall be held on the first Tuesday of each month, at such hour as the Board may designate, and unless otherwise ordered shall be holden at the office of the Board. Special meetings may be called at any time by the chairman, and shall be called by him upon the request in writing of two members of the Board.

3. At the annual meeting of the Board, or as soon thereafter as may be, the following standing committees shall be chosen by ballot: —

A Committee on Finance.

A Committee on Publications.

A Committee on Water Supplies and Drainage (acting under chapter 274, Acts of 1886).

A Committee on Public Institutions.

A Committee on Food and Drugs.

A Committee on Legislation and Legal Proceedings.

A Committee on the Health of Towns, and Correspondence with Local Boards of Health.

A Committee on Contagious Diseases.

4. Four members shall make a quorum for the transaction of business.

A committee on registration and vital statistics was added to the list of committees, and the committees were made up as follows: —

Finance. — Messrs. BATES and APPLETON.

Publications. — Messrs. WALCOTT, APPLETON and DRAPER.

Water Supply and Sewerage. — Messrs. MILLS, WALCOTT, LOTHROP, JONES and BATES.

Public Institutions. — Messrs. WALCOTT, MILLS, JONES and BATES.

Food and Drugs. — Messrs. WALCOTT, JONES and DRAPER.

Legislation and Legal Proceedings. — Messrs. LOTHROP, APPLETON and BATES.

Health of Towns and Correspondence with Local Boards of Health. — Messrs. DRAPER and MILLS.

Contagious Diseases — Messrs. JONES, WALCOTT and DRAPER.

Registration of Vital Statistics. — Messrs. DRAPER, WALCOTT and JONES.

The duties of the Board as defined by the statutes consist in the "making of sanitary investigations and inquiries in respect to the causes of disease, and especially of epidemics, and the sources of mortality and the effects of localities, employments, conditions and circumstances on the public health and the gathering of such information in respect to those matters as it may deem proper for diffusion among the people." In addition to these duties it is required that the Board "shall advise the government in regard to the location and other sanitary conditions of any public institutions."

To these duties are also added the requirement that the Board shall investigate the prevalence of small-pox and other contagious or infectious diseases, co-ordinate powers being conferred upon it with the local boards in such matters.

The Board has also the power to prohibit the exercise of noxious and offensive trades, and by certain Acts of 1882 and 1884 the supervision of food and drug inspection was also entrusted to it.

One of the most important of its duties is that conferred upon the Board by the Act of 1886 (chapter 274), relative to the protection of the inland waters of the State from pollution.

WATER SUPPLY AND SEWERAGE.

In 1886, a very important law was enacted entitled "An Act to protect the purity of inland waters," by which the general oversight and care of such waters was committed to

the State Board of Health. Under this act the Board was authorized to employ such experts as were necessary for carrying out its provisions, to recommend legislation and suitable plans for main sewers, to report its proceedings under the act, and to submit estimates of expenses.

It was also required to make examinations of such waters with reference to their domestic use, and authority was granted to conduct experiments for determining the best practicable methods of sewage purification and disposal.

The Board was also required to consult with and advise the authorities of cities and towns, and also corporations, firms and individuals, with reference to existing or proposed systems of water supply and sewerage.

An act so broad and far-reaching in its general provisions must have a salutary effect as a protective sanitary measure, and, in fact, such effects are already evident in not a few instances, as will be seen in the detailed report of proceedings of the Board under the provisions of chapter 274 of the Acts of 1886.

The Board entered upon the duties required in this act in July, 1886, and the report of the work done during the following six months may be found in the eighteenth annual report of the Board.

During the past year, for the purpose of carrying out the provisions of the act more fully, a regular system of chemical analysis of all the domestic water supplies in the State has been organized under the charge of Prof. T. M. Drown of the Massachusetts Institute of Technology. At the same time the services of Mr. George H. Parker were secured for the purpose of making examination of the same waters with reference to the presence of algæ and other forms of vegetable life, which should be found present in the different water supplies.

At a later period Dr. E. K. Dunham was also appointed to conduct a parallel series of bacteriological examinations upon the same waters, and entered upon his duties immediately after his arrival in this country.

Continuous observations have also been conducted with reference to the quality and quantity of the principal streams of the State, and an important series of experiments have

been undertaken at Lawrence with reference to the use of different soils for the purpose of sewage filtration, under the direction of Mr. Mills.

Full details of these operations of the Board, as well as the data with reference to the consultations required by section 3 of the same act, will be found in the report of the Board required by this act. It is quite evident that the important duties required by this act, with the inquiries therein provided for, must necessarily replace and supersede the mere statistical data which are called for by the Act of 1879, chapter 80, sections 103, 104 and 105, the publication of which, under the existing statutes, would be an act of supererogation, requiring extra labor and expense, the result of which could have no additional practical value. The repeal or amendment of the former act is therefore desirable.

Sewerage of the Mystic and Charles River Valleys.

By a resolve of the Legislature enacted June 16, 1887, the State Board of Health was "authorized and directed to consider and report a general system of drainage and sewerage for the relief of the valley of the Mystic River, and so much of the Charles River, if any, whose relief, in the opinion of the Board, is to be sought in conjunction with the Mystic Valley system."

This question, already brought to general notice in the reports of two previous commissions appointed in 1881 and in 1884, is one of great importance as affecting the welfare of a populous and rapidly growing section of the State. As the report of the Board upon this question is not called for until 1889 it is only necessary to add that the Board began active operations under the provisions of this resolve during the past season. Competent engineers have been appointed with instructions to consider the question under the various methods of sewage disposal upon land, of chemical precipitation, and of disposal of the crude sewage into the out-going tide.

The Sewage-Disposal of the Village of Medfield.

One of the earliest schemes for the disposal of the sewage of a town, which was submitted to the State Board for its advice under the provisions of chapter 274 of the Acts of

1886, was that of the town of Medfield. This plan provided for a village of about 1,500 inhabitants, and included the sewage of a manufacturing establishment employing about 400 operatives. As this town is situated in the upper portion of the valley of the Charles River, and above the points at which the water-supplies of several cities and towns are taken, it was desirable to purify the sewage as thoroughly as possible before the admission of the effluent to the river.

The method of disposal of the sewage at that place is by intermittent filteration, upon a small tract of land which is quite favorable, both in the character of its soil and also in its location, for such disposal.

A description of this plan of disposal at Medfield, by Fredk. Brooks, C. E., will be found in the Report.

Weekly Mortality Reports.

These reports comprise the weekly returns of deaths occurring in the cities and principal towns of the State, which embrace nearly two-thirds of the population of the State. They are made up at the close of the week and are forwarded to the office of the Board, where they are tabulated, published and forwarded to all of the cities and towns. The returns from the cities and large towns are published weekly, and those from the smaller towns monthly.

The data contained in these returns comprise the total deaths in the reporting towns, the deaths of children under five years of age, the deaths from the principal infectious diseases and also the meteorological data for the year.

Offensive Trades.

The only case which was brought to the notice of the Board during the year, under the provisions of the Offensive Trades Act, was that of E. F. Jennison, the proprietor of an establishment used for fat-rendering and soap-making, and located upon the south bank of the Charles River in Newton, near the Watertown line. This case was mentioned in the last report of the Board (p. xxviii), where it was stated that a hearing was granted, and upon evidence being presented of the offensive character of the establish-

ment and the consequent annoyance of people living in its neighborhood, the proprietor agreed to make such changes in the methods of conducting his business as should prevent further nuisance, and was allowed to continue his business.

During the past summer numerous complaints were received, alleging that the works were still as offensive as ever, and it became quite plain that such an establishment could not be maintained in that locality without being a nuisance. Additional evidence of such nuisance having been presented to the Board by persons living in Watertown, and also by an inspector of the State Board, the following action was taken at a meeting of the Board held August 16, 1887 : —

The Board adjudges and determines the business of rendering, carried on by E. F. Jennison of Newton, to be a nuisance and detrimental to the public comfort and convenience, and the Board orders him to cease and desist from carrying on his trade of rendering on the premises now occupied by him for the purpose of carrying on such trade, on and after the first day of September, eighteen hundred and eighty-seven.

A copy of this order was served upon Mr. Jennison on the following day. The order was not complied with, and the attention of the attorney-general was therefore called to the fact that Mr. Jennison had failed to comply with the order of the State Board.

Upon receiving notice from the attorney-general, Mr. Jennison discontinued his business of fat-rendering. Subsequently, complaints were received by the attorney-general that the place had become a nuisance again in consequence of the storage of offensive material, and on further notice he removed his business from that place to another town.

Contagious Diseases.

During the past year, as in the previous year, there has been an unusual immunity from infectious and contagious diseases, and in no case have outbreaks of contagion assumed so threatening and wide-spread a character as to require an investigation by the State Board,— as is required by section 2 of chapter 80, Public Statutes,— with two ex-

ceptions hereafter detailed. Careful inquiry has also been made as to the origin of certain cases of small-pox which occurred in the winter and early spring, nearly all in cities and towns west of the Connecticut River.

The two instances referred to are those of West Falmouth and Maynard. In the former, diphtheria appeared early in the spring of 1886. The population of the village is quite small. It is located on Buzzard's Bay, on the East Shore, with a location naturally healthful, and the land sloping gradually toward the bay, the soil being mainly of sand and gravel. The whole number of cases was not over twenty-five and the deaths about one-fourth as many. These cases were distributed throughout the year, and the disease did not finally cease to prevail until December. The cause of the spread of the disease, so far as could be learned by inquiries made from house to house and inspection of the premises, appeared to be a too free communication between the families of the sick and of the well. The sanitary condition of premises did not differ much from that of country farm-houses. The proximity of the well to the privy-vault, cellar and sink drainage, and that in a loose and porous soil, may have contributed in some instances to the propagation of the disease.

The following analyses of the water of some of the wells used by families in which the earlier cases occurred were made at the direction of the Board: —

	Date of Coll. Anal.	Unfiltered.		Chlorine.	Residue.			Nitrates.	Hardness.
		Ammo.	Alb. Ammo.		Fixed.	Volatile.	Total.		
	1886.								
"A" * .	Sept. 15,	0.0372	0.0128	2.2	4.5	3.6	8.1	None.	3°
"B" † .	"	0.0064	0.0062	1.3	4.9	3.1	8.	None.	1.5°
"C" ‡ .	"	0.0126	0.0164	3.	5.7	2.6	8.3	None.	1.5°

* Much charring on ignition of residue; clear; odorless; very slight color.

† Slight charring on ignition of residue; clear; colorless; ordorless.

‡ Much charring on ignition of residue; slightly turbid; brownish color; earthy odor.

Disinfection was conducted in nearly, if not quite, all the cases at the direction of the local Board.

The town of Maynard presented a petition to the State Board of Health requesting it to "investigate the existence of typhoid fever and diphtheria, and the means of preventing the spread thereof."

The Secretary, therefore, conferred with the local Board as the proper and legally authorized sanitary officers of the town; also with the local physicians, and also with a considerable number of the petitioners.

It is sufficient to say that the spread of the two diseases in question is undoubtedly promoted by the presence of filth, and in a town of so rapid growth as Maynard, where wells used for drinking water are located in densely populated neighborhoods, many must necessarily be in close proximity to vaults and cess-pools, as I found them to be on the day of my visit.

It may not be possible to state definitely the cause of disease in a particular case, unless it be true that in certain cases of diphtheria the persons attacked were not sufficiently isolated from contact with others. This, however, appeared to have been remedied by more careful measures adopted in September and October.

A definite code of health regulations was recommended as a valuable aid to sanitary work, and certain other matters were also noted, which, although not directly, were indirectly related to the questions referred to in the petition, such as the sanitary condition of certain portions of the town, the dumping-ground for refuse, and night-soil upon the land of the mill corporation, which, while it was not offensive on the day of the visit, might readily become so at the times when deposits of noxious material are made at that place. Upon more careful consideration the present place in a near neighborhood of inhabited dwellings was not regarded as a suitable place for making such deposits. The necessity of better drainage in the populous part of the town was also pointed out.

Small-Pox. — During the latter part of the winter and early spring several cases of small-pox were reported to the Board from the western counties of the State, in compliance

with the Statutes of 1883, chapter 138, which requires that the Board of Health of each city or town in which a case of small-pox occurs shall, within twenty-four hours after the receipt of such notice, notify the State Board of Health of the same.

The first case was reported from Boston, February 12, 1887. The only comment worthy of note in regard to this case is that the patient was a Scotch immigrant who came to this country in September, 1886. The notice to this Board contains the following comment: "The patient arrived in Boston from New York city on the 29th of January, and therefore must have contracted the disease in the latter city."

The cases which were reported next occurred in Holyoke, also in February.

The following is the Secretary's report of these cases, and also of the following outbreaks in Huntington and Dalton : —

Report of Outbreaks of Small-Pox in Paper-Mill Towns.

Notice having been received of the occurrence of three cases of small-pox at Holyoke, the Secretary, in company with Dr. C. F. Withington, visited the place on the 3d of March, 1887, for the purpose of inquiry. The agent of the mill gave every facility for making such inquiries as were necessary.

"The Parsons Paper Company is one of the older paper companies at Holyoke. It employs about 300 operatives, and manufactures envelope paper and fine grades of writing paper, using for this purpose rags of several sorts, both foreign and domestic. About one-half of the rags used are foreign rags, and of those in use during the past winter there were two lots, German and Russian, coming from the port of Hamburg, and collected mostly at Koenigsberg. These had been kept in bulk for about two years in a store-house before being baled, and had been submitted to the sulphur process. They were marked S. P. F. F., and also with the mark of the inspector, Dr. Horatio R. Bigelow, as having been disinfected by him. They were mainly coarse white linen rags of a pretty even grade and quite free from dirt.

The domestic rags were of two sorts. First, clean new

shoe lining cuttings from Eastern Massachusetts; and second, old rags of all sorts from New York, Philadelphia, Baltimore, Albany and other cities. Many of these were dirty rags. These came to the mill in bales, and after variable periods of time, from a few days to a few weeks, were opened, and the dirty rags put into the duster in the lower story of the mill. This duty was performed by J—— L———, an unvaccinated Irishman, who came to the United States a few months before. He handled all the rags, both foreign and domestic, both kinds in the course of each day. All these rags were submitted to the process of dusting in the same machine, and often both sorts of rags were in the machine upon the same day.

J—— L——— left the mill on the 18th of February on account of illness, and his illness proved to be small-pox, of which he died at the small-pox hospital a few days after his admission.

From this dusting-machine the rags are taken to the sorting-rooms, which are in the same part of the mill, two stories above the duster. The sorting-rooms are light and well ventilated by revolving fans, and at the time of my visit were unusually clean and free from dust. The other parts of the mill presented a very clean and orderly appearance.

The foreign rags and the clean shoe-cuttings were sorted in the smaller room, and the domestic old rags were sorted in the larger room. In the smaller room, which communicated with the larger room by a door, about 35 women were employed. These women passed through the larger room four times each day in going to and from their work.

Two girls employed in the smaller room were taken ill; one of them left her work February 12, with symptoms which were not well defined. She did not have decided symptoms of small-pox until February 19. This girl was 16 years of age, and stated that she had been vaccinated in infancy, but not since then. She was an emigrant from Ireland and arrived in the United States a few months previous. The cicatrices were not typical vaccine scars.

The other girl, aged 22, was also Irish, and had been in the United States but a short time. She was taken ill February 19. She also professed to have been vaccinated in

infancy, and in her case also the cicatrices were faint and not typical. She had, according to her statement, been re-vaccinated without success.

All these persons were taken to the small-pox hospital, and the two girls had a favorable recovery, the disease being mild in both cases.

It is my opinion that in these three cases rags were the probable medium of contagion. Pursuing the inquiry farther, as to the sort of rags which probably conveyed the disease, it is impossible to come to a definite conclusion. The foreign rags had been stored in bulk in a foreign warehouse for two years and handled by operatives there without producing infection, and had then been subjected to disinfection by sulphur and afterward baled, and then submitted to a long sea-voyage.

At the mill these rags, in common with the domestic rags, had been handled by J—— L———, who had carried both sorts of rags to the duster. Hence in his case all possibility of identifying the medium of contagion is lost. The violent agitation which the process of dusting imparts to the rags also leaves a portion of the dust in the machine to be mixed with the next charge of rags. Hence in this machine all identity of contagion must be lost, since both sorts of rags are dusted in it, and often on the same day.

With reference to the domestic rags, the clean shoe-cuttings may be disregarded as improbable carriers of infection. The old rags from cities must be regarded with suspicion, a portion of them having been collected in New York city, from which place they were received within a short interval of time, and also without disinfection. In New York and also in Brooklyn small-pox had been prevalent for several weeks at the time of the outbreak at Holyoke.

While it is true that the two women who were attacked were engaged in sorting foreign rags and shoe-cuttings only at that time, and for a few weeks previously, the foregoing facts should also be taken into account, and also the fact that they daily passed through the sorting-room where the domestics (dirty rags) were sorted. I must therefore conclude that it is not practicable to ascertain whether the contagion was produced through the medium of foreign or domestic rags."

Notice was received of the occurrence of two more cases at Huntington on the Westfield River. The Secretary went to Huntington, April 8, and ascertained the following facts: —

"The Chester Paper Company in this town employs about fifty-five operatives, and makes a fine quality of writing paper, using for this purpose both foreign and domestic rags. About twenty per cent. of foreign rags are used. The foreign rags are Russian and Italian (Leghorn). The domestics are of two sorts: A portion from cities, New York and elsewhere; and also colored country domestics collected in the neighborhood of Kinderhook and Rochester, N. Y.

These rags are dusted, all in the same machine, on the same floor with the sorting-room to which they are conveyed. In this room are employed about fifteen women and five men and boys.

One of the women employed in this room, Mrs. Collins, aged 21, was taken ill about Saturday, April 2, and left work, her illness proving to be small-pox. She had never been vaccinated.

In the same room there was also employed a French-Canadian woman, aged about 55, who had been vaccinated when young, presenting upon her arm one typical cicatrix. She also said that several members of her family had had small-pox. A granddaughter of this woman, aged 12 or 13, frequently visited the mill where her grandmother worked, and so far as could be learned, occasionally helped her. This girl was attacked April 2. No physician was at first employed, and she was seen in the street with an eruption on April 4 or 5. On inquiry at the house by the town authorities, admission was at first refused. A physician was then sent and he pronounced the case one of small-pox. This girl had never been vaccinated, and at the time of my visit was thoroughly covered with the eruption."

In regard to the question of the medium of contagion in these cases, as in the former cases at Holyoke, the rags appear to be the probable medium.

As to the question whether the foreign or the domestic rags are at fault, the same perplexity arises as in the former case, and no definite conclusion can be given.

In consequence of the greater nearness of New York city (from whence a portion of the rags were received), both in time and in space, and the existence of small-pox at that place, the probability is in favor of the domestic rags as the medium of contagion.

At this paper mill further inquiries were made which showed a serious neglect on the part of its proprietors in their disregard of one of the important sanitary provisions of the statutes.

At the time of this visit there were fourteen persons in the sorting-room of the mill, as follows: —

Six Irish women and three French women from 40 to 60 years of age; one American woman aged 25; one girl aged 18; three boys aged 16 to 19.

Of these women five claimed to have had the small-pox, and therefore refused vaccination. In one only of these could any traces of the disease be discovered.

Another woman aged 52 says she was vaccinated at the age of 2 years and not since then.

The boys had been vaccinated in infancy and also re-vaccinated on the day before my visit.

Another woman aged 50 was vaccinated at 10 years and not since that time.

A French woman aged about 40 has no mark of vaccination.

An Irishwoman aged 40 was vaccinated in infancy, has one typical cicatrix, and has not been re-vaccinated.

Mrs. Collins, one of the victims, an employee, was never vaccinated.

The three public schools in the centre of the town were visited, where the children of mill operatives are taught. About three-fourths of the scholars had been vaccinated within the past week, and measures were being taken to vaccinate the remainder."

In the same month another case was reported from the town of Dalton, the victim being also an employee in the Weston paper mill in that town. There were at that time about one hundred operatives employed, of which number seventy were in the sorting-room. The condition of this

room was unusually clean and free from dust. The rags here used were mostly new, such as collar cuttings and new linens. About one-third were Leghorn rags which had been washed and disinfected before shipment. They were very free from dust and dirt and of a very uniform quality.

On May 9 a case was reported from Westfield in the person of an Irishman, a laborer, whose wife was employed in a paper mill in that town. It was also stated in the notice that the rags in use in that mill were "new domestic rags." This man died May 16. His sister was also reported May 19 as having small-pox. She also died.

June 11 a case was reported from Granville, Mass., the victim being another sister of the former patient, and the notice states that "this girl went to visit her brother who was sick at Westfield, and it was found that he had the small-pox."

A fatal case was also reported from Cambridge May 12, the victim being a laborer in a pork-packing house. The report states of this case: "It is reported that some of his relations at Lowell, Mass., had what was pronounced by one doctor small-pox, and measles by another, about three weeks ago. One of these relatives visited this man here since then."

The remaining cases were two Italian immigrants who arrived in New York in May. They came to Boston, and the husband developed small-pox two weeks after his arrival. Two weeks later the wife "contracted the disease from her husband."

The statutes relative to the vaccination of the employees of incorporated manufacturing companies should apply with special force to paper mills, which from causes already shown are especially liable to outbreaks of small-pox among their operatives, but the matter should not cease with them. It is especially desirable, and it is the custom in some cities, that the local boards of health should make careful inquiry of all such corporations, with reference to the execution of this statute. It would be an additional safeguard if such an inquiry were made, personally, by some member of the Board or agent charged with such duty, and at stated inter-

vals of one or two years, without reference to the prevalence of epidemics of disease.

The following is the law to which reference is made : —

Incorporated manufacturing companies, superintendents of almshouses, state reform schools, industrial schools, lunatic hospitals, and other places where the poor and sick are received, masters of houses of correction, jailers, keepers of prisons, warden of the State prison, and superintendents or officers of all other institutions supported or aided by the State, shall at the expense of their respective establishments or institutions cause all inmates thereof to be vaccinated immediately upon their entrance thereto, unless they produce sufficient evidence of previous successful vaccination within five years. — *Public Statutes, chapter 80, section 54.*

The following is a summary of the foregoing cases reported to the State Board of Health (under Statutes of 1883, chapter 138) : —

1887.

No.	Place of Occurrence.	Date of Report.	Nativity.	Cases.	Deaths.	Employment.	Previously Vaccinated.
1	Boston,	Feb. 12,	Scotland,	1	-	Baker,	In childhood.
2	Holyoke,	" 28,	Ireland,	1	1	Paper-mill operative,	No.
3	Holyoke,	" 28,	Ireland,	1	-	Paper-mill operative,	In infancy.*
4	Holyoke,	" 28,	Ireland,	1	-	Paper-mill operative,	In infancy.*
5	Huntington,	April 5,	Massachusetts,	1	-	Paper-mill operative,	No.
6	Huntington,	" 6,	French Canadian,	1	-	Paper-mill operative,	No.
7	Dalton,	May 6,	Massachusetts,	1	-	Paper-mill operative,	In infancy.
8	Cambridge,	" 12,	Ireland,	1	1	Laborer,	Unknown.
9	Westfield,	" 9,	Ireland,	1	1	Laborer,†	Doubtful.
10	Westfield,	" 19,	Ireland,	1	1	-‡	No.
11	Granville,	June 11,	Ireland,	1	-	-‡	No.
12	Boston,	May 19,	Italy,	1	-	-	In infancy.
13	Boston,	June 1,	Italy,	1	-	-	In infancy.

Fortunately, by careful isolation, vaccination and other sanitary precautions these outbreaks were confined to the first cases which occurred in most instances. In none of them did the outbreaks extend beyond the families or immediate relations of those who were attacked.

* Vaccine scars very doubtful in character.
† This man's wife was employed in a paper-mill.
‡ Sisters of Number 9.

In consequence of these outbreaks in paper-mill towns the following circular was issued by the Board, and sent to all the local boards of health in the State: —

Office of State Board of Health,
13 Beacon Street, Boston, March, 1887.

VACCINATION.

A Circular from the State Board of Health.

In consequence of the continued prevalence of small-pox in cities in neighboring States, which are in constant communication with Massachusetts, the State Board of Health would call the attention of local boards to the necessity of vaccination and re-vaccination in their respective cities and towns.

In times of immunity from epidemics of small-pox the practice of vaccination in many cities and towns in the Commonwealth has been neglected, and a large part of the population, born since the last epidemic, remains unvaccinated; the truth of this statement, admitted by those having large experience in sanitary administration, has been verified by the recent correspondence of this Board. While the statutes relative to vaccination as a prerequisite to school attendance are carefully complied with in most cities and large towns, this provision is not carried out in others.

As an example of the deplorable results of municipal neglect in these matters the recent experience of Montreal may be quoted, where, in a total of 3,164 deaths from small-pox in 1885, 2,036, or 64 per cent., occurred among children under five years of age, and 86 per cent. among children under ten.

It is also urged that local boards of health should take special pains to carry out, as far as lies in their power, the provisions of the statutes relative to vaccination, by making provision for general vaccination of the unvaccinated and re-vaccination of those who have not been recently vaccinated, and also by securing the enforcement of the statutes relative to vaccination as a prerequisite to school attendance and employment in mills and workshops.

Attention is also called to the requirements of chapter 138 of the Acts of 1883, which provides for immediate notice to the State Board of the existence of cases of small-pox.

The custom, observed by many physicians, of vaccinating all infants born in their practice within a few months after their birth, is commended by this Board as being worthy of general adoption, as is also the practice of continuing such vaccination at short intervals, until the operation gives absolutely negative results.

There were also reported to this Board, from other State and provincial boards of health, six cases of small-pox during the year, as follows: —

From Connecticut, one case, February 19.
Montreal, one case, March 4.
Connecticut, one case, April 21.
Connecticut, one case, May 30.
Maine, one case, June 30.
Rhode Island, one case, July 18.

These cases were reported in compliance with the following resolutions, which were adopted by the International Conference of State Boards of Health held at Toronto, Ontario, Oct. 6, 1886: —

WHEREAS, It is necessary for the protection and preservation of the public health that prompt information should be given of the existence of cholera, yellow fever and small-pox; be it

1. *Resolved*, That it is the sense of the National Conference of State Boards of Health that it is the duty of each State, provincial and local board of health in any locality in which said diseases may at any time occur, to furnish immediately information of the existence of such diseases to boards of health of neighboring and provincial States and to the local board in such States as have no State board.

2. *Resolved*, That upon rumor or report of the existence of pestilential disease, and positive definite information thereon not being obtainable from the proper health authorities, this Conference recommends that the health officials of one State shall be privileged and justified to go into another State for the purpose of investigating and establishing the truth or falsity of such reports.

3. *Resolved*, That whenever practicable, the investigations made under the preceding section shall be done with the co-operation of the State or local health authorities.

4. *Resolved*, That any case which presents symptoms seriously suspicious of one of the aforenamed diseases, shall be treated as suspicious, and reported as provided for in cases announced as actual.

5. *Resolved*, That any case respecting which reputable and experienced physicians disagree as to whether the disease is or is not pestilential, shall be reported as suspicious.

6. *Resolved*, That any case respecting which efforts are made

to conceal its existence, full history and true nature, shall be deemed suspicious and so acted upon.

7. *Resolved*, That in accordance with the provisions of the foregoing resolutions, the boards of health of the United States and Canada represented at this Conference do pledge themselves to an interchange of information as herein provided.

It is quite plain that the action thus taken will avail but little so long as the larger and more populous States refrain from reporting cases which may occur within their limits.

Neither scarlet-fever nor diphtheria has prevailed to an unusual degree during the year until November, when the former gradually increased, and became epidemic to such a degree in Boston, Cambridge and Somerville that it was deemed advisable to close a few of the lower grades of schools in places where it was unusually prevalent.

Infectious Diseases as connected with Milk Supplies.

The subject of the public milk supply as a medium of communication of certain infectious diseases is one which should receive careful attention on the part of local boards of health. The almost universal use of milk as an article of food (and that in an uncooked condition), the various processes to which it is subjected in its manipulation from the time when it is drawn from the cow until it is finally received into the digestive organs of the consumer, render it a most probable vehicle for the transmission of infection. The various accidents and conditions to which it is exposed begin with the animal herself, for while the food of the animal has an undoubted effect in modifying the quality of the milk, it is not yet proven that such food is capable of transmitting infectious disease through the animal to the milk. But it is now considered as quite well established that certain diseases, notably scarlet-fever (and possibly tuberculosis), may be communicated directly from the cow through the milk which she produces, in consequence of the existence of the disease in the animal at the time of milking.

Further than this, other infectious diseases, such as typhoid fever and diphtheria,—especially the former,—have been

repeatedly shown to have been communicated from the family of the dairyman through the medium of the milk to the families of consumers. The opportunities for such infection of milk, when infectious disease exists at the farm-house, are not difficult to find. The various processes to which the milk is subjected include the milking of the animal, for which purposes men are employed who may have come with unwashed hands from the bedside of a child sick with infectious disease. The milk is transferred to cans which may have been washed with water from a polluted well or other water supply, to say nothing of the possible dilution of the milk with considerable quantities of the same water for fraudulent purposes, — and finally the milk may be distributed to the consumer by one or more persons who are in intimate communication with the sick member or members of the family, or have just come as convalescents themselves from the sick-room to engage in the work of milk distribution.

These are not mere possibilities but are known as actual occurrences, and serve to show the necessity of the greatest care in the sanitary management of the milk supply; and also of infectious diseases which may occur in the household of the dairyman, especially with reference to their isolation and disinfection.

The water supply and drainage of the farm-house, and also of the stables or dairy, are also of the greatest importance and should receive the most careful attention.

In March Dr. I. H. Hazelton of Wellesley reported the following cases: —

On March 3, 1887, I was called to see Alfred M., four years six months old, who was taken the evening before with vomiting, bleeding at the nose, high fever during the night, soreness of the throat and restlessness. I found the boy with high temperature, 103.4 degrees; rapid pulse, 120; with a fine eruption over the face and neck; tonsils swollen, with pultaceous deposit; and the submaxillary glands enlarged. The family took milk of D. R. On March 6 the eruption had extended over the entire body; on the 8th the boy was convalescent. Later desquamation took place, the only unpleasant after effect being enlarged tonsils and submaxillary glands, which had entirely disappeared April 1.

On March 9 I was called to see Mabel R., seven and one-half

years old, living nearly a mile from the former patient, with the same symptoms as in the former case only a little less violent. *The family took their milk of the aforesaid D. R.* April 15 this child was entirely well.

On March 11 I was stopped in the road by a man who requested me to call upon his two children who were quite sick. I asked him whom he took his milk from, and he answered, "D. R." I pronounced the disease scarlet-fever and told him I would call on my return. He lived about two hundred yards from the first patient, but there had been no communication between the two families except by the milkman. I found the two boys Willie A., four years (sick four days), with faint eruption over the whole body and sore throat, and Joseph A., seven and one-half years, with the sore throat, slight eruption on face and neck, mild fever (taken sick the day before). The disease was mild with Willie and very slight with Joseph. Both made good recoveries.

March 11, I went into Boston and made a verbal report to the State Board of Health; on the next day Dr. Abbott brought out Dr. Austin Peters and we proceeded to the shed of D. R., not over eighteen feet long, ten wide and eight and a half feet high, where two cows were kept. The one that gave the milk for all three families was found to have on the udder an eruption. No cases had been reported to the town Board of Health for a year. A very pronounced fact was that the first child was much the sickest, the severity of the symptoms decreasing in each successive case.

I. H. HAZELTON.

The following is the report of Dr. Peters, who was requested to examine the animals referred to in Dr. Hazelton's report. It will be noticed that Dr. Peters does not consider the evidence conclusive so far as a personal examination of the inspected animals is concerned: —

BOSTON, March 14, 1887.

DR. S. W. ABBOTT, *Secretary of Massachusetts State Board of Health.*

SIR: — Having accompanied yourself and Dr. Hazelton of Wellesley on a visit of inspection at the dairy of D. R. of that place, in order to find out whether it had any connection with an outbreak of scarlatina among the children of some of his customers or not, I beg leave to submit the following report: —

The premises were visited Saturday morning, March 12, 1887, and found to contain two cows, both rather old and in not partic-

ularly good flesh. The stable was a cow shed capable of holding four or five cows. It would compare favorably with the accommodations generally afforded cows of this class. It was not a luxurious one, but at the same time it might have been much worse.

Upon a close examination of the udders of the animals, one of them was found to have a slight eruption. The skin was somewhat thickened and roughened at a few points (perhaps eight or ten), around the base of the teats chiefly, and these points also had a reddish appearance. On one teat was a small pustule about the size of a large pin's head, containing a drop of pus. A little serum exuded from one of the blotches on pressure.

The udder of the other cow was healthy. The health of both animals seemed in other respects to be good. Upon my return home to Jamaica Plain I visited the barn of a milkman living near by and examined the udders of ten cows. Five of them had a slight eruption resembling the one on the udder of the cow at Wellesley Hills, and yet there is no scarlatina in our neighborhood, which he supplies with milk.

I believe it to be no uncommon occurrence for milch cows at this season of the year to present this appearance of the mammary gland, as a result of irritation produced by contact with the bedding, the floor, manure, urine, etc.

Dr. Klein in his report on the outbreak of scarlatina in London, says: "The cows which were first the subjects of my investigations had on the teats and udder several flat, irregular ulcers, varying in diameter from $\frac{1}{4}$ to $\frac{3}{4}$ of an inch. Some ulcers were more or less circular, others extended in a longitudinal direction on the teat." "The ulcers were covered with a brownish or reddish brown scab, which when scraped away left exposed a granulating, slightly indurated base." "The margin of the ulcer was not raised, nor was there any perceptible redness of the skin around." He then goes on to say, that in the earlier stages "it was noticed that a small vesicle made its appearance on a greatly swollen and red teat, in the course of a couple of days assuming the character of the above ulcers." "In another cow an ulcer about $\frac{1}{2}$ an inch in diameter was becoming covered in its central part with a scab, while at its margin vesiculation was still distinctly visible."

The ulcers also leave a cicatrix when they heal.

It will be seen from this description that the eruption which we witnessed Saturday did not resemble the one seen by Dr. Klein, and that also a similar eruption to the one we saw at Wellesley Hills may exist on the udders of cows supplying a milk route on which no scarlatina exists.

I believe the subject to be one worthy of still further investigation, as the appearances described by Dr. Klein might be found in a future outbreak of scarlatina.

Yours respectfully,

AUSTIN PETERS, M. R. C. V. S.

Having learned that diphtheria had been prevalent in Melrose and Malden, in connection with certain milk supplies, Dr. J. S. Clarke was requested to report upon the same.

Dr. Clarke has presented the following summary of cases :

"Of the several cases occurring in my own practice I failed to discover any of the classical grounds, or *loci causæ*, obtaining, but incidental inquiry elicited the fact that each had a common milk supply, and further investigation found it also true in the cases of other physicians. In Melrose twenty-three cases occurred in twelve families. In one of these families the contagium was from immediate contact with contiguous neighbors, who were down with the disease.

We have, therefore, eleven distinct foci of infection widely separate (two only being within the same square), being generally near a line from north to south, of two miles in extent, at intervals of one-eighth of a mile. At these eleven foci of infection, or original cases, a certain local vendor served seven with milk, another two, another one, and a fourth one, while these four obtained milk from two wholesale dealers, who, on their part collected it in a neighboring town and district where diphtheria was then prevailing, and *from families in which diphtheria then existed.* If these were coincident phenomena they attain to the marvellous, when we consider that, of probably thirty distributors of milk, this disease only followed in the trail of a certain supply and failed to appear on the routes of twenty or more who drew their supply elsewhere and none of whom peddled this particular milk.

In the interest of truth and to satisfy an awakened curiosity as to the extent of the mischief wrought by this milk supply, I pursued it in its effects still further. Being furnished with a list of cases in Malden, for the same period, I continued my investigations with the following results : Number of cases reported, twenty-seven ; number of families in which they occurred, eighteen ; of these one was not to be found, and one claims to have contracted the disease from a neighbor in whom it existed and with whom they intermingled freely. Now, of the sixteen foci of infection to be accounted for, thirteen received the infected milk. Of the remaining three, who were served by two vendors who received

their main supply from the cars, no history is obtainable, but it is quite possible that it came from this very infected locality. . . .

We have, therefore, an epidemic of diphtheria extending over four miles in length, including fifty subjects of this disease in thirty families, or twenty-eight distinct foci of infection. No facts can be had in one instance, thus leaving twenty-seven to be dealt with. Of these twenty-seven foci of the disease twenty-four were supplied with milk coming direct from families in which the disease was known to exist, leaving three only wherein we fail to make out a case that would warrant a verdict for conviction. Of the fourteen deaths resulting from this epidemic, thirteen were in families using the milk known to be infected, and one in the family in which no history is had. We emphatically assert that thirteen deaths were the immediate result of an infection conveyed by milk supply, *the mischief of preventable cause.*

The data relative to the foregoing cases are as follows : —

Data concerning Diphtheria in Malden, in June, July and August, 1886.

Foci of Infection.	Family.	Street.	Date of Report.	No. Cases.	No. Deaths.	Vendors of Milk.	Whole-sale Dealer.	Source of Supply.
1	R.,	214 Main, .	July 1,	2	–	C. P. S.,	R.,	Don't Know.
2	S.,	66 Ferry, .	Aug. 28,	1	–	S.,	"	" "
3	P.,	35 Cedar, .	" 28,	1	–	"	"	" "
4	E.,	25 Myrtle, .	July 1,	4	–	A.,	B.,	North Reading.
	R.,	28 Myrtle, .	" 10,	2	–	C. P. S.,	–	–
5	S.,	Pratt Ave., .	Aug. 12,	1	–	A.,	B.,	North Reading.
6	W.,	Hamlet Pl., .	July 29,	1	–	M.,	M.,	" "
7	D.,	5 Waverly Pl.,	" 10,	1	–	N.,	G.,	" "
8	B.,	Ferry, . .	Aug. 26,	1	1	"	"	" "
9	O.,	5 Washington,	July 28,	1	1	"	"	" "
10	W.,	Pleasant, .	" 23,	1	–	"	"	" "
11	K.,	2 Washington,	" 16,	2	1	W.,	H.,	" "
12	W.,	5 Franklin, .	" 29,	1	–	"	"	" "
13	W.,	Abbott Ct., .	" 12,	2	–	C.,	"	" "
14	C.,	Seaview Ave ,	" 16,	2	2	"	"	" "
15	F.,	Granite, .	" 27,	1	–	"	"	" "
16	D.,	Charles, . .	Aug. 31,	1	1	H.,	"	" "
17	D.,	52 Haskins, .	" 2,	2	1	–*	–*	–
				27	7			

Foci No. 4.—R. children played with the E. children, and in the yard of the former daily.

* Can't be found, moved away.

Data concerning Diphtheria in Melrose, in June, July and August, 1886.

Foci of Infection.	Family.	Street.	Date of Report.	No. Cases.	No. Deaths.	Vendors of Milk.	Wholesale Dealer.	Source of Supply.
1	N.,	Melrose, .	June 9,	1	–	F.,	B.,	North Reading.
2	B.,	Ashland, .	" 17,	3	–	W.,	"	" "
3	R.,	Ashland, .	Aug. 2,	1	–	"	"	" "
4	K.,	Pleasant, .	July 13,	1	1	U.,	H.,	" "
5	D.,	Trenton, .	" 13,	1	1	W.,	"	" "
6	G.,	Vinton, . .	" 19,	1	1	"	"	" "
*7	P.,	Albion, . .	" 15,	3	2	"	"	" "
	W.,	Albion, . .	" 26,	2	–	–	–	–
8	K.,	Winthrop, .	" 26,	5	1	W.,	H.,	North Reading.
9	–	Essex, . .	Aug. –,	2	1	"	"	" "
10	C.,	Waverly, .	" 5,	1	–	"	"	" "
11	K.,	Linden, . .	" 17,	2	–	"	"	" "
				23	7			

* No. 7.—The family of W. adjoined the former, and children were constantly together. W's used milk from own cow.

The reporter also states that diphtheria also appeared in two families in North Reading, to whom milk was supplied by one of the dealers mentioned in this report; and three children died of the disease in these families.

Typhoid Fever in Connection with Milk Supply.

In a similar line of investigation is an inquiry of the Board relative to a local epidemic of typhoid fever which occurred in Cambridge in November, 1886.

The following reports of Drs. Harrington and Jackson will serve to illustrate some of the points already mentioned:—

Boston, Mass., January, 1887.

Dr. S. W. Abbott, *Secretary State Board of Health.*

Dear Sir:—I have the honor to report on the investigation of the milk supply which is supposed to have been the cause of the recent outbreak of typhoid fever at Cambridge.

On January 4, in company with Dr. Henry Jackson and Mr. John H. Terry of this city, I went to Suncook and Hookset, N. H., for the purpose of inspecting the farms of Messrs. Whittemore,

Mann, Morgan, Howe and Sullivan, who supplied milk to Mr. Wright, on whose milk route the majority of cases occurred. Specimens of water for chemical and biological analysis, and of milk for biological analysis alone, were taken from each farm. The report on the biological analysis will be made by Dr. Jackson: —

Howe Farm.

The Howe farm was the first visited. The live stock appeared to be in good condition; the barn and other out-buildings were in good order and fairly clean. The water supply is a constant stream conducted through iron pipe from a spring 75 rods distant, and discharging into a wooden trough in the yard. There was no history of sickness occurring at the farm for some months.

Morgan Farm.

At the Morgan farm the stock and buildings were in good condition. The pump was situated in the barn cellar, which was to a considerable extent covered with solid and liquid manure. Contamination of the water supply would not have been surprising. There was no history of any sickness.

Sullivan Farm.

At the Sullivan farm everything appeared clean and very carefully kept. Running water comes through iron pipe from a spring in the woods 100 rods distant. There was no history of illness.

Whittemore Farm.

At the Whittemore farm the cows looked thin and out of condition. The cow stable and other out-buildings did not appear to be well kept. There was a general slovenly appearance about the farm and its owner. The water supply is derived from a well situated between the house and a graveyard. The well is about 80 feet from the latter, from which to the well there is a slight downward slope. The soil is light, open and sandy. Opportunity for contamination of the water seemed very favorable. There had been no history of sickness.

Mann Farm.

At the Mann farm the live stock and buildings were in excellent order. The water for the barn and dwelling is obtained from a well 26 feet deep, bricked and curbed. The water is conducted to a pump in the barn, standing about 6 feet from a brick privy-vault. The latter was well built of brick and cement, and seemed

to be quite tight. There was no odor or perceptible leakage. The lead pipe passes from the pump directly by the vault, a few feet below the surface of the cellar floor, to the well, which is about 18 feet from the vault. Inquiry as to any present or past sickness was at first answered in the negative. Hearing from a neighbor, however, that there had been "slow fever" at the Mann farm, we returned and renewed our inquiries. On re-examination, Mr. Mann recollected that his son had not felt well early in September, and on September 13 had kept his bed with typhoid fever. The description of the symptoms left no doubt in our minds that the diagnosis of the attending physician was correct. Mr. Mann took entire charge of the nursing. He stated that he emptied the excreta every day into the privy vault and always covered them with dirt or ashes. The attack lasted several weeks; convalescence was rapid. The boy had been up and about his work since the 1st of November. He had been living at home for about a month before he was attacked. Mr. Mann's farm-hand left him about November 1, and was attacked three weeks afterward with the same disease.

A few days after this man had departed, Mr. Mann, assisted by his second son, cleaned out the vault, the contents of which were thrown out on the ground near by and covered with sand.

The epidemic at Cambridge broke out on or about November 18, which is about the time that the discharged farm-hand was seized. It will be noted that the latter left the farm before the vault was cleaned out.

Chemical Analysis of the Water.

The chemical analysis of the five samples of water proved to be completely negative. With one exception they were of excellent quality, — far better than the average of good waters. The only water which showed impurity was that which was obtained at the Howe farm. That specimen showed a somewhat large amount of albuminoid ammonia, which was doubtless due to vegetable matter. The free ammonia and chlorine were very low in amount, and indicate absence of animal pollution.

The figures (expressing parts in 100,000 of water) obtained by analysis were as given below: —

LOCATION.	Free Am-monia.	Albu-minoid Am-monia.	Chlor-ine.	Residue.			Hard-ness.
				Fixed.	Volatile.	Total.	
* Howe (running water), .	0.0006	0.0118	0.25	1.3	1.6	2.9	1°
* Sullivan (running water),	0.0000	0.0034	0.20	3.1	0.9	4.	1.5°
* Morgan (well), . .	0.0044	0.0020	1.65	4.5	2.3	6.8	2°
* Whittemore (well), .	0.0004	0.0026	0.20	2.7	1.2	3.9	1°
* Mann (well), . . .	0.0000	0.0046	1.60	6.5	2.2	8.7	4.5°
Cambridge water (Nov. 27),	0.0456	0.0238	2.30	9.6	8.2	17.8	8°

Soakage may have occurred from the Mann vault into the soil, but there is no evidence to show it. At the time the vault was cleaned out the ground was frozen and the excreta would therefore have had some difficulty in penetrating to the well. It would seem, moreover, as though any serious pollution in November would have left some traces even so late as January 4. It is probable — very probable — that the cases in Cambridge were due to the milk from the Mann farm, but the exact method of contamination is not yet shown. It would perhaps be instructive to make a second examination when the frost is out of the ground.

Respectfully,

Charles Harrington.

Report on the Bacteria found in the Water and Milk of five Farms in Suncook, N. H., by Dr. Henry Jackson, Jan. 12, 1887.

Jan. 4, 1887, I went to Suncook, N. H., to examine the water and milk of the following farms to ascertain, if possible, whether a sufficient or probable cause for typhoid fever could be found either in the water or in the milk.

At each farm a specimen of the water and of the milk was collected in a sterilized bottle with glass stopper. The water was, in each instance, that in use by the family and for the cattle; the milk was taken directly from the cans of mixed morning milk.

Jan. 5, gelatine plate cultures were made from each of the specimens collected; thus it will be seen that twenty-four hours necessarily passed before the cultures could be made, allowing time for the bacteria originally present to increase in number.

Howe Farm.

Running water in cow yard, the water coming from a hill behind the house, and at considerable distance from any buildings.

* All clear, colorless and odorless. No nitrates.

Specimen of water taken from the trough as it bubbled up through a wooden pipe.

Jan. 8, were found 250 to 300 colonies of bacteria in one cubic centimeter of the water.

The following varieties were distinguished: —

(*a*) Elevated brown colonies of vigorous growth, microscopically round cocci found.

(*b*) Rapidly growing colonies, causing liquefaction of the gelatine and the formation of a white flocculent sediment; microscopically thick very short rods.

(*c*) Elevated fine white colonies, causing no liquefaction of gelatine; thick rods about twice as long as they are broad. In milk, specimen taken from a cool room in the house, were found by estimation 2,000 colonies: (*a*) raised brown colonies, cocci; (*b*) white colonies, liquefying gelatine, microscopically short rods.

Remarks.

Bacteria in water more numerous than they should be in good potable water. Before condemning the water, however, two factors must be considered: (1) The water in the trough is constantly open to contamination from outside sources (cows drinking, etc.). (2) Twenty-four hours elapsed before the cultures were made.

WHITTEMORE FARM.

Pump near the house but on higher ground; soil sandy. About 100 feet from the well is a graveyard situated higher than the well; graveyard seldom used, according to the statement of the farmer.

Jan. 8, were found in one cubic centimeter of water nine colonies: —

(*a*) Brown elevated, microscopic cocci.

(*b*) White, not much elevated, non-liquefying; microscopically short thick rods.

In milk, 100 colonies. Most of the colonies in the milk appeared microscopically the same variety. Microscopic examination of several showed small round cocci; a few brown colonies, microscopic cocci. The water may be considered as practically free from bacteria. Milk was in a cold shed.

MORGAN FARM.

Water taken from a pump in a cellar under the barn; cellar contained manure and urine in large amount.

Jan. 10, in one cubic centimeter of water, fourteen small colonies: —

(*a*) Several pure white colonies, microscopically small, perfectly round cocci.

(*b*) Yellowish-white colonies, microscopically thick rods, about twice as long as they were broad; after a week slow liquefaction of gelatine.

Milk contains, in one cubic centimeter, many hundred small white colonies and a few brown colonies: (*a*) white colonies, microscopically minute round cocci; (*b*) brown colonies, microscopically pretty large oval cocci.

Water contains a small number of bacteria, and in winter at any rate is not contaminated by the overlying excrement.

Sullivan Farm.

Running water in cattle yard coming from a hill about one quarter of a mile distant from the house.

Jan. 8, in one cubic centimeter of water forty colonies: —

(*a*) Chiefly raised brown colonies, microscopically short thick rods.

(*b*) A few small white colonies, microscopic cocci.

Considering the exposure of the water to external contamination the specimen contained very few bacteria.

Milk in cool room in house contained thirty non-liquefying white colonies, microscopic cocci.

Mann Farm.

Pump in barn; water brought from a well, some eighteen feet distant from the privy, through a lead pipe lying very near the privy, to the pump. In this house there have been, during the autumn, two cases of typhoid fever. The dejecta of one case were emptied into the privy.

Jan. 8, in water, forty-eight colonies: —

(*a*) Nine small colonies liquefying the gelatine and making a white flocculent sediment; microscopically short thick rods.

(*b*) Thirteen small white colonies with slight depression of surrounding gelatine; microscopically short thick rods.

In milk (can in the barn), in one cubic centimeter about 1,000 small white colonies, microscopic cocci, many arranged in pairs as diplococci.

The water cannot be considered bad.

To sum up: —

(*a*) No bacteria have been found that can be considered as pathogenetic.

(*b*) So far as the number of bacteria determines the quality of water, —

That from the Whittemore and Morgan farms is good, being practically free from bacteria.

That from the Mann and Sullivan farms cannot be considered to contain an undue number of bacteria.

That from the Howe farm is probably contaminated, from some source, with organic matter.

The milk from the Sullivan and Whittemore farms contained comparatively few bacteria; that from the other farms a large number.

But the examination gives no ground for the supposition that pathogenetic forms are present.

HENRY JACKSON.

INSPECTION OF FOOD AND DRUGS.

The laws giving authority to the State Board of Health with reference to food and drug inspection were enacted in 1882 and the succeeding years, and the active work of the Board in this direction, in connection with that of the previous Board, covers a period of about four years.

So far as the actual prevalence of adulteration is concerned, the experience of the Board during the past year confirms that of previous years, in showing that constant watchfulness is necessary to prevent the multitude of adulterations which occur, either through the avarice or the carelessness of men. By far the greater number of such adulterations consist in the addition or the substitution of substances of similar character to the original product, for the purpose of lessening its real value. Such substitutions are not usually of an actively injurious character, although in many instances the actual nutritive value of the food in question is impaired in proportion to the extent of the adulteration, and also to the deficiency in nutritive value of the substitute employed.

The positively injurious adulterants are mostly the various mineral poisons, such as are employed for the coloring of certain articles of food. Occasionally poisons are introduced accidentally in the process of soldering tin cans used in preserving. Other poisons which occur in the process of food inspection are those which are sometimes developed in the food, during or after its manufacture, as in the case of poisonous cheese.

The law thus has a two-fold operation, sanitary and economical. Protection has been afforded against harmful ingredients in food, and on the other hand the pecuniary advantage secured by the execution of the law has proved to be far greater than the costs of its administration.

Full details of the work done under the provisions of these acts will be found under the head of *Food and Drug Inspection*.

Oleo-margarine and Butterine.

During the past five years or more, and since the rapid increase of the products known as oleo-margarine and butterine as a part of the food supply, several questions relative to the regulation of their sale have received the attention of the Legislature, resulting in certain statutes, enacted during the past few years, mostly pertaining to the proper methods of marking these products.

The question of their wholesomeness as food for general use had not received much attention.

The Legislature of 1887, after considering the matter, enacted the following resolve, committing the subject to the State Board of Health and requiring them to report to the Legislature of 1888: —

Ordered, That the State Board of Health be requested and required to make a special investigation and report to the next General Court upon the manufacture and sale of oleomargarine and butterine, especially with reference to their healthfulness as articles of food, and as to the question whether they are sold in compliance with existing laws. — *June 3, 1887.*

The subject of this order admits of a triple division as follows: —

1. The manufacture and sale of the products in question.
2. Their healthfulness as articles of food.
3. The execution of the laws relating to them.

For the investigation of the second division of the subject, including the sanitary aspect of the question, the Board

appointed Dr. E. G. Brackett of Harvard Medical College, whose results, together with such material as the Board has collected relative to the other topics, will be found in this volume.

Trichinosis.

Inquiries have been continued throughout the year with reference to the prevalence of trichinosis in swine. So far as the people are concerned there is not much to be feared in a community where thorough cooking of all pork is the rule,— since it is in this custom that the remarkable immunity of our population consists. There has been but one authentic case of death from this disease in Massachusetts in twenty years or more, while in some portions of Germany fatal epidemics attacking considerable numbers of the population in small villages where the eating of raw pork is common are not by any means rare. In Hedersleben there were 337 cases and 101 deaths in one epidemic, and in Emersleben 403 cases and 66 deaths in a single epidemic.

The examinations conducted for the Board have been under the care of Prof. E. L. Mark of Harvard University, and have been made upon the flesh of hogs from various sources, including Western hogs, those raised in the neighborhood of Boston, whose feed consisted largely of the swill and refuse of the city, and others from the public institutions of the State, raised under varying conditions of feeding. These inquiries are still progressing and will be reported upon in a future report of the Board.

Tuberculosis in Cattle.

This important subject has thus far received but little consideration in the United States. It deserves careful attention, however, in consequence of its frequent occurrence and the possible transmission of it from the cow to her offspring, and also to other animals and perhaps to mankind.

The Massachusetts Society for the Promotion of Agriculture has undertaken a valuable inquiry into the history and characteristics of this disease, and the matter having been brought to the attention of the State Board of Health,

the Board expressed its approval of the contemplated action of the society.

Public Institutions.

By the act of 1886, creating the present Board, it was required to "advise the government in regard to the location and other sanitary conditions of any public institutions."

Under this requirement the following questions have been submitted to the Board during the year: —

1. The subject of the plumbing, ventilation, and sewage disposal of the Lunatic Hospital at Westborough.
2. The drainage at the State Normal School at Westfield.
3. The hospital of the State Reformatory at Concord.
4. The proposed location of the Massachusetts School for the Feeble-Minded.
5. An extension of the plan of sewage disposal at Sherborn.
6. Certain questions relative to the sewerage and plumbing of the State Industrial School at Lancaster.
7. Certain questions relative to the plumbing and drainage of the State Lunatic Hospital at Danvers.

State Lunatic Hospital at Westborough. — A request was received April 8, 1887, from the trustees of the State Lunatic Hospital at Westborough that the Board "should examine the system of drainage at the hospital and recommend a proper method of the disposal of sewage." On further consultation with the trustees, in compliance with this request, it was found that other conditions beside those of drainage and sewage disposal required sanitary inspection, and the Board, having considered the questions submitted to them, replied to the trustees as follows; so much of the letter as does not relate to the questions of water supply and sewerage being quoted here, and the remainder under the transactions of the Board under the provisions of chapter 274 of the Acts of 1886: —

To the Trustees of the Westborough Lunatic Hospital.

Gentlemen: — In accordance with your written request of April 8, that the State Board of Health would examine the system of sewage disposal at the hospital, and recommend a proper dis-

posal of the sewage, and in accordance with the verbal request that the Board should further examine the sewage disposal within the hospital, having in view such aid as may be thus given the trustees in guarding against the re-occurrence of cases of diphtheria, some of which then existed, the State Board of Health immediately took the matter in hand, and on the 14th of April a committee of this Board with its engineers visited the hospital with two members of the board of trustees, and have since given careful consideration to the conditions there existing.

The general system of heating and ventilation consists of drawing air in through a cellar window across a coil of steam pipes, which moderates its temperature, then a fan throws it into a section of the cellar (say one-quarter of the whole area), from which it enters under other steam coils and goes up through them directly into flues to the rooms to be heated and ventilated.

The cellar varies in height from nine to two feet under the floor timbers, and the bottom is covered with a layer of concrete of hydraulic cement and sand. Some of the walls are dry stone walls ; some appear to be laid in cement, and some to be pointed up with mortar. But neither floors nor walls are impervious to ground air, and when the ground surrounding the building is frozen in winter or filled with water to a foot in depth, it is evident that with a fall in the barometer the ground air for a large area around the building will find an outlet into the cellar and will, in considerable quantity, mix with the air entering by the fan and going to the rooms. If the ground around or under the building has been polluted by drains or otherwise, as is reported to be the case adjacent to some parts of this building, the ground air entering the cellar is not suitable to be supplied to the rooms of the hospital.

There are seasons when the fans are not run at night, and the ground air forms a considerable fraction of the air entering the rooms. This ground air has been found to contain from five to forty times as much carbonic acid as fresh country air, and in the judgment of the Board the ducts taking air to the living-rooms should be tight flues separated from the ground by free air spaces, and not subject to being supplied with ground air.

On this general principle the Board would recommend that tight flues should be constructed, conveying all air for heating and ventilation from some distance above the ground, outside the building, into the receiving-room containing the steam coils, which room should be tight, and have its floor and sides separated by a clear, free air space from the ground and the outer walls of the

building. The fan should then throw the air through tight flues to the coils under the flues running to the rooms, all arranged so that no air from the cellar can enter them, and the cellar should be thoroughly ventilated.

These conditions of construction should be complied with if there were no other objections to your present system than have been mentioned, but they are specially needful and essential in the present case, because in a considerable part of the cellar the courses of the air from the fans to the upright flues are lined or crossed by water-closet and other drainage pipes, which convey all of the liquid filth from the hospital.

These pipes are in short lengths having bill-joints made with lead at an average distance apart of two and one-half feet. Of fifty-four joints, a distance of one hundred and fifty-four feet, one-half were found defective; twelve joints were leaking; eight joints have leaked at one time; in eight joints the lead had opened so as to show a crack; twenty-six show no defect.

The sewer-pipe system was designed to be well ventilated, and under ordinary conditions, with the steam boilers in operation, the ventilation of the pipes would be unusually effective. In their present condition in the lower and more confined parts of the cellar the pollution of the air in early morning is offensively apparent, and though this can be improved by having all the pipes in the cellar replaced by more expensive pipes with flanged joints, it is impossible to remove all of the objections which attend the running of sewer-pipes through and along the passages through which the air for heating and ventilating the hospital is brought.

Besides these sewer-pipes there are a number of catch-basins into which the cellar drains, which, receiving much water through the walls of the cellar from rains which fall around the building, are at this wet season trapped; but in a dry season, with the ground around the buildings properly graded, the cellars would be relieved of their present dampness, and the cesspools would become untrapped by evaporation, and let in foul air from the old drain-pipes with which they are connected.

The Board of Health concludes that air drawn from a cellar at times damp with water percolating through the surrounding ground, at times dry with liability of untrapped connection with old drains, — each cellar containing long lines of sewer-pipes with a large number of joints, liable to be imperfect, — is not the air that should be supplied to hospital wards or the sleeping-rooms of attendants, although this air is diluted during the day by fanning into the cellar at three points fresh air from outside ; and

during the night stopping the fans, leaving three or more windows open to replace the air of the cellar which rises to the rooms.

This system should, in the judgment of the Board, be replaced at the earliest practicable moment by a system of tight passages, separated from the ground and from the air of the cellar, conveying fresh air from out of doors directly to the rooms; and so long as the method of supplying air is by fans, these should be run at all times when the heat in or under the several flues is not sufficient to convey the requisite amount of fresh air to the rooms and cause in them an excess of pressure.

State Normal School at Westfield. — The Board received in April last a plan of a proposed sewer in School Street, Westfield, together with a request that the Board would examine and report whether the plan proposed was the best method of relieving the State Normal School and Boarding Hall of the ill effects which they experienced from the present condition of the drainage in their immediate neighborhood.

The Board, having examined the proposed plan and location at Westfield, replied to the request, and their reply will be found in the special report of the transactions of the Board, under the provisions of chapter 274 of the Acts of 1886, entitled "Water Supply and Sewerage."

Hospital of the Massachusetts Reformatory at Concord. — The following request was received from the Prison Commissioners April 23: —

OFFICE OF THE COMMISSIONERS OF PRISONS,
STATE HOUSE, BOSTON, April 23, 1887.

HENRY P. WALCOTT, M.D., *Chairman State Board of Health.*

SIR: — I am directed by the Commissioners of Prisons to request that the State Board of Health will cause an examination to be made into the sanitary condition of the hospital at the Massachusetts Reformatory, with a view to determining whether it can properly be used for its present purposes, and if not, whether it is feasible to so improve the ventilation that it can be so used.

Yours truly,

W. F. SPALDING, *Secretary.*

In compliance with this request, the Board, after an examination of the hospital apartment at the Reformatory, replied to the commissioners as follows: —

May 13, 1887.

Gentlemen: — In response to the request of the Board of Prison Commissioners of April 23, the State Board of Health visited the hospital at the Massachusetts Reformatory with a view to determining whether it can properly be used for its present purpose, and if not, whether it is feasible to so improve the ventilation that it can be so used.

The hospital was found to be a large octagonal room, eighty or more feet across and about twenty feet high, lighted by large and high windows giving exposure to the sun at all hours of the day. It is heated by steam radiators in four quarters of the room and a stove in the middle. There are some half dozen short flues extending from the top of the room for the outlet of heated air, but none for the inlet of fresh air. There is, however, an inlet for polluted air which is a serious injury to this room when used for any purpose, and especially so if used for a hospital. This inlet is through the elevator shaft, which serves as a discharging flue of the foul air of the top of the guard-room and the top of the open spaces surrounding the cells of all the wings.

To appreciate the possible effect, let us assume a medium temperature at night with heat admitted to the hospital but none in the cells of the wings, and the door of the elevator in the hospital opened occasionally and certain holes that exist in the top of the elevator shaft open all of the time.

The flues above the hospital discharging at a much higher level than those from the cells, and discharging warmer air, there appears to be nothing to prevent the foul air in the attic over the cells into which cells and water-closets are ventilated going down through the ventilating flues of the cells, coming out into the open space around the cells, and being drawn up into the hospital and taking the place there of the air going out through the hospital flues; thus making the hospital a mixing chamber of the worst gases discharging from all the cells of the institution. The condition thus presented is an extreme one, but it differs only in degree from the actual condition prevailing. Much of the foul air from the cells and galleries must go every night through the hospital.

This condition is not necessary and may be easily remedied. The elevator shaft should be extended to the top of the hospital room, with an outlet to external air through the wall near the top.

It should also be cased with a tight casing down through the guard-room from ceiling to floor, with a door for entrance which shall be kept closed when not in use.

This will effectually cut off the supply of foul air from the guard-room through the elevator shaft. If any foul air rises through the floor of the hospital, as was suggested, this may be readily cut off by laying a tight upper floor upon a layer of asbestos board, which may be fitted tight around the steam pipes.

In this way the hospital may be cut off from contamination from the guard-room; after which it may be ventilated by admitting fresh air properly warmed through flues arranged to supply it without draught upon the inmates, as is usual in well constructed hospitals.

The Board of Health concludes that as at present arranged the sanitary condition of the hospital at the Massachusetts Reformatory is not such that it can be properly used for its present purposes, but that it is entirely feasible to so improve the ventilation that it can be so used. While thus answering questions presented by the Prison Commissioners, the Board does not wish to give the impression that, in designing such an institution, they would necessarily decide this to be the best place for the hospital.

By order of the Board,

S. W. Abbott, *Secretary.*

Massachusetts School for the Feeble-Minded.—The School for the Feeble-Minded is located at South Boston. It has also a farm-house and farm in the town of Dover. It was decided to remove the school to a more desirable location and to combine these two branches of the institution at one place, for which purpose several locations were proposed in Sharon, Needham and Waltham. The trustees having submitted the question to the State Board of Health, all of these places were visited and carefully examined by the engineer and the secretary of the Board with reference to the future needs of the institution. The location at Waltham near the Belmont line and also quite near to the Convalescent Home of the Massachusetts General Hospital was finally selected and approved by the Board in the following vote:—

That the lot of land in the city of Waltham, selected by the trustees of the Massachusetts School for the Feeble-Minded, is approved by the State Board of Health as a suitable site for the proposed new building of the school.

State Reformatory at Sherborn. — The method of sewage disposal conducted at the State Reformatory for Women at Sherborn is that of subsoil filtration upon a tract of land near the prison. The Board of Commissioners of Prisons having under consideration the extension of the system to another tract of land, and to conduct the disposal at that place by surface irrigation, submitted the question to the State Board of Health. A statement of the action of the Board with reference to this subject will be found under the title of "Water Supply and Sewerage." (Report upon chapter 274, Acts of 1886.)

State Industrial School at Lancaster. — The trustees of the State Industrial School at Lancaster, having deemed it necessary to improve the sanitary condition of the School, submitted the question to the State Board of Health, which, by its Secretary, replied as follows: —

BOSTON, Sept. 26, 1887.

M. H. WALKER, *Chairman of Trustees of State Primary and Reform Schools.*

DEAR SIR: — In compliance with the request embodied in your letter of September 17, I have visited the State Industrial School at Lancaster, and would respectfully make the following suggestions as to the sanitary improvements at that institution.

The plumbing in the brick buildings Nos. 1, 2 and 4 should receive a careful inspection by an expert, with special reference to leaks in pipes. Better fixtures should be introduced in the water-closets which will admit of a thorough flushing with water, the present water service being entirely inadequate. The slop-sink is in an objectionable position in the bath-room of No. 2 and should be placed elsewhere, and with a form of fixture which can be kept clean and well-flushed.

The following suggestions should be applied to all buildings where brick vaults, used for the reception and storage of sewage of any kind, are partially or wholly under, or in close proximity to such buildings. Such vaults should be removed and also the earth around them, so far as it may be found to be saturated with filth or sewage, and the pipes leading to them should be connected directly with the drains leading from the buildings and a proper trap introduced at the cellar wall. The same suggestion applies

to the farm-house, where a good water-closet should be introduced, properly protected from danger of freezing.

The practice of storing sewage underneath or in close proximity to inhabited buildings is open to serious objection.

The final disposal of sewage in the field at the rear of the buildings appears to be at a proper distance from them, and may be freed from objection by a more uniform distribution on the surface of the soil. The cesspools or settling basins in the field will undoubtedly answer their purpose if kept covered and frequently inspected.

In one of the brick buildings the direct ventilation of a water-closet into a school-room, at a point where the heated air of the school-room must necessarily draw the foul air of the closet into the school-room, should receive proper attention.

Respectfully yours,

S. W. Abbott, *Secretary.*

The State Lunatic Hospital at Danvers. — The ventilating shafts at this institution carry the fresh outer air, propelled by a large fan, directly to the steam coils in the basement of the hospital. Each of these shafts is drained by a small tile-pipe running parallel with, and below the shaft. Into one of these tile-pipes was conducted the condensed steam from the coffee-boilers in the kitchen. A leak in one of the boilers allowed the escape of the coffee to the drain, where it produced an offensive odor in those parts of the institution which are furnished with fresh air from the ventilating shafts under which this tile-pipe was located. The defects which caused this trouble had been detected and remedied before the time of the inspection made by the Board.

Ventilation and Heating of School-Houses.

Considerable attention has been given in past reports of the Board to the subject of school hygiene, and especially to the matter of ventilation. It is not uncommon, however, to find that an undue share of attention has been given to the schools of populous communities, to the neglect of the schools of smaller size and to the buildings in which they are placed. A very large part of the school population of the State lives in small towns and villages, often in sparsely

settled districts, in which the buildings usually contain one or two rooms at the most. The sanitation of this class of buildings is of as much importance as that of buildings of the larger class, containing from three to a score of separate schools, and often having several hundred scholars. In the former class the usual method of heating is by means of stoves, the more expensive methods by hot water and steam being out of the question. Dr. J. G. Pinkham of Lynn has given this matter of the heating and ventilation of single rooms and small school-houses careful attention, and has presented his results in a paper in the present report.

Registration of Vital Statistics.

During the past year the State Board of Health was requested by the Secretary of State to take charge of the editing of the registration report. This report comprises, in addition to the returns of births, marriages and deaths, a summary of the statistics of divorce as required by the Statutes of 1882, chapter 194, and also the returns of the medical examiners as required by the Acts of 1885, chapter 379. The following is a brief summary of the facts presented in the forty-fifth registration report for the year 1886 : —

Population.

The population of the State had increased from 1,783,085 in 1880 to 1,942,141 in 1885, an increase equal to 1.78 per cent. annually. This increase of 159,056 in five years was mainly due to immigration. The natural increase by the excess of births over deaths in the same period being 49,505, leaving 109,551 to be accounted for by immigration. The estimate of population for 1886 has been made upon the supposition that the same rate of increase continued from 1885 to 1886, which would indicate a population of 1,976,264.

Births, Marriages and Deaths.

The number of births recorded by the registration officers in 1886 was 50,788 ; the number of marriages, 18,018 ; and of deaths, 37,244 ; the number of births was also 1,998 more, the marriages 966 more, and the deaths 850 less than those of 1885. The excess of living births over deaths was 13,544, which indicated a natural increase of the population of 2,848 greater than that of the previous year, and also greater than the natural increase

of any year since 1860, except 1874. Assuming the population to have been 1,976,264 for the middle of the year 1886, the rates would have been as follows: —

Birth rate per 1,000 of the population, ...	25.7
Marriage rate (persons married), ...	18.2
Death rate, ...	18.8
Excess of births over deaths.	6.8

This would indicate one child born alive to 39 persons, one person married to 55, and one death to 53 living persons.

Births.

The number of births recorded in 1886 was greater than that of any year since registration was begun, and the rate of living births, 25.7, was also greater than that of any year since 1875.

The ratio of male and female births, 104.6, did not differ materially from that of the previous 33 years, which was 105.

Illegitimacy.

One thousand and thirty births were recorded as illegitimate in 1886, which was greater than that of any previous year and indicated a rate of 20.3 per 1,000 births. There has been a progressive increase in this respect, the ten years 1867–1876 showing a rate of 11.2 illegitimate births per 1,000, and the ten years 1877–1886 a rate of 18.1 per 1,000 births.

These rates are much less than those of European countries, that of England and Wales being 53 per 1,000, of Scotland 92 per 1,000, and of Bavaria 152 per 1,000 for a period of ten years.

Marriages.

The number of marriages was 18,018 as compared with 17,052 in 1885 and 17,333 in 1884. The number of persons married was 18.23 per 1,000 of the estimated population and the number of marriages 9.12 per 1,000. This was a higher rate than the average of the past ten years and also lower than that of the past twenty years.

Deaths.

The whole number of deaths registered was 37,244, a decrease of 850 as compared with those of 1885, and also 128 less than the average of the past five years.

This would indicate a death rate of 18.8 per 1,000, which was less than that of any year since 1879.

No great epidemics occurred during the year, and the facts presented relative to births and deaths show that the year was one of more than average good health.

If the State is divided into two groups of counties, according to the density of the population, the following facts are shown: —

One of the groups comprises the counties of Suffolk, Essex, Middlesex, Bristol, Norfolk and Hampden, and the other group comprises the remaining counties.

The former group includes nineteen of the twenty-three cities and all of the large cities except Worcester, and may be called the urban or manufacturing group. In this group the density of population in 1885 was 442 persons to the square mile and the death rate of the same group was 19.7 per 1,000 of the population.

The latter or agricultural group had a density of 102 persons to the square mile, and a death rate of 17.7 per 1,000.

The infant mortality of the year 1886 was for children under one year 20.9 per cent. of the total mortality or a little more than one-fifth of the whole, which was but little more than the average of the past fifteen years. For children under five years it was 31.6 per cent. of the whole, which was considerably less than the average of the past fifteen years, 34 per cent.

The ratio of deaths from unknown causes, as compared with the total mortality, has steadily diminished from year to year from 5.5 per cent. in 1868 to 1.2 per cent. in 1886, a fact which is undoubtedly due to improved registration laws as well as to a better discrimination as to the causes of diseases, and also to greater care on the part of physicians in the matter of making certificates of deaths.

The diseases commonly known as zymotic, a class which includes a greater number of those which may be considered as indicative of the sanitary condition of any community, presented a smaller ratio to the general mortality than that of any previous year.

Constitutional diseases showed but little change as a class for the past ten years, while local diseases have shown a very marked increase from year to year. The developmental and violent deaths have presented but little change.

Of the principal zymotic or infectious diseases, measles produced a mortality of but 130, which was less than half the average death rate for this disease for a period of thirty years.

For the first time since the beginning of registration in 1842 an entire year has elapsed without the registration of a single death from small-pox.

Scarlet-fever was also much less destructive than usual, the death rate for this disease for 1886 being but little more than one-fourth of the average for the past thirty years. It is also worthy of note that if the entire period of thirty years, 1857–1886, be

considered, the mortality rate from this cause for the last half of the period (1872–1886) was but little more than half as great as that of the first half (1857–1871).

The mortality from diphtheria and croup has shown but little change for the past five years. The deaths from these causes in 1886 were 1,558, as compared with 1,523 in 1885. For the preceding five years (1877–1881) the number was much greater, ranging from 3,178 in 1877 to 2,383 in 1881. The number of deaths from typhoid fever in 1886 was 800, which was slightly more than that of 1885, but less than the average of the past ten years. It is gratifying to note that this disease, which more than any other is an index of local sanitary conditions, has notably diminished in its frequency within the past twenty years.

The number of deaths from diarrhœal diseases was 3,339, of which number 1,931 were from cholera infantum, 243 from dysentery and 500 from diarrhœa. The mortality from whooping-cough was 271, nearly all of which was among children under five years of age.

The most destructive of all diseases, consumption, caused 5,897 deaths, of which 2,766 were of males and 3,131 were females. The mortality from this disease has slightly diminished within the period of twenty years, the average rate of mortality from it in the decade 1867–1876 being 33.7 per 10,000 of the population, and that of the following decade 1877–1886 being 31.2 per 10,000.

Still more marked have been the changes in the mortality from cancer, the mortality from this disease in 1886 being 1,104, of which 770 or 69.7 per cent. were among females. The mortality rate from this disease has increased from 3.6 per 10,000 in the decade 1867–1876 to 5.2 per 10,000 in the decade 1877–1886.

Among the statistics of mortality a table is presented showing the increase in the number attributed to Bright's disease for a period of thirty-seven years. The increase is in a great measure an apparent rather than a real one.

Medical Examiners' Returns.

By an act of 1885 it was required that the deaths which are made the subject of special inquiry by the medical examiners should be reported to the secretary of the State, and the statistics compiled by him should be published in the Annual Registration Report.

The whole number of cases examined during the year was 1,378, of which 47 were deaths from homicide, 181 by suicide, 678 from accident or negligence and 496 were from other, mainly natural, causes.

The number of autopsies made was 202, and the expense attendant upon the operation of the medical examiner laws was for the medical portion of the work $18,024.22.

The enactment of this law has secured to the State a system much more efficient, more economical, and far more satisfactory in every particular than the ancient coroner law, which for more than two centuries had preceded it.

Local Boards of Health.

The existing statute relative to the choosing of local boards of health is permissive only, and provides that any town at its annual town meeting *may* choose a board of health, and in default of such choice the selectmen shall constitute the board of health.

In consequence of this indefinite provision about one-half of the towns neglect to choose boards of health, and the sanitary interests of such towns are therefore committed to bodies of men whose duties are already complex, and who are not specially qualified for the administration of sanitary work.

The want of a properly constituted sanitary board has proved a serious hindrance to the execution of public sanitary measures in many towns, the boards as at present constituted being often reluctant to use the power which the statutes confer upon them in regard to the control of contagious diseases, the removal of nuisances, and other matters relative to sanitary administration.

The State Board has abundant evidence in its possession, not only of the inefficiency of the present statute, but also, in some cases, of its being an actual opponent of sanitary progress.

Should it not be deemed practicable to require the appointment of an independent sanitary authority in every town, a law might be enacted which would limit such action to towns of more that one thousand inhabitants.

The following bill was reported in 1881, and has many excellent features: —

Section 1. In each of the several towns of this Commonwealth the board of selectmen shall, in the month of January,

appoint two persons, neither of whom shall be a member of the board of selectmen, and one of whom shall be a physician (provided there be a resident physician), who, together with the chairman of the board of selectmen shall constitute the board of health of such town.

The board so constituted shall enter upon its duties on the first Monday of February then next succeeding. The terms of office of the appointed members shall be so arranged at the time of their appointment that the term of one shall expire on the first Monday in February of each year.

In each of said towns said boards of health shall annually, in the month of January, present to the State Board of Health a report made up to and including the thirty-first day of the preceding December, upon the sanitary condition of the towns during the year.

Some of the objections formerly urged are removed in this bill by conferring the duty of appointment of the local board upon the selectmen. The bill also contains a provision for an annual report from each local board to the State Board of Health, which may be reckoned as a decided advantage, since the health authorities of each town would be brought into more immediate relation with the State Board, whereby they might the more readily obtain that advice and assistance desirable in the administration of sanitary affairs. The State Board would also be enabled to secure a correspondent in each town in the State.

Further objections might be removed if necessary by the limitation of the action of the bill to towns of a definite number of inhabitants.

This measure was deemed of sufficient importance to have received the sanction of the Governor in his Annual Message of 1885, and is certainly of no less importance at the present time.

Office and Laboratory Accommodation.

Under the provisions of the acts relative to food and drug inspection the Board is authorized to "appoint inspectors, analysts and chemists," and by the Statutes of 1886 relative to the "protection of the purity of inland waters," it is also authorized to "employ such engineers and

clerks and other assistants as it may deem necessary," and also " such expert assistance as may be necessary."

The efficient execution of these laws could not be properly accomplished without the employment of a considerable corps of analysts, engineers and other experts such as the statutes authorize. For such purposes the Board has fortunately secured excellent assistance, but the officials employed for these purposes are scattered here and there in several different offices, laboratories and parts of the State, and a considerable portion of the appropriations must necessarily be employed in paying the rentals of different apartments for such uses as are here named.

It is also a matter of no inconsiderable inconvenience that the different laboratories and offices should not only be at a distance from each other, but also from the office of the Board, since many of the experimental inquiries and different lines of engineering work required under these acts necessitate constant comparison, one with another. It is, therefore, a matter worthy of serious consideration, that these different departments should be provided for, and thus be brought more closely in contact with each other under a single roof, as convenience and economical considerations would dictate.

In addition to the foregoing summary of the matters which have received the attention of the Board, the following items of interest are also presented : —

Twenty meetings of the Board have been held during the year, and, also, frequent meetings of committees, especially of the committee on Water Supply and Sewerage, and also of sub-committees.

The Board has also been represented at hearings before Legislative committees, when its presence was requested by such committees.

Visits have been made by the Board to the Boston Improved Sewerage Works, to the Saugus marshes, to Lake Cochituate and Farm Pond, to the Lawrence Experimental Station, to the Westborough Hospital, and by sub-committees, or by officers of the Board, to many other places where their presence was required.

Hearings have been held during the year by the full Board relative to the following matters : —

The Rendering-works of E. F. Jennison, ...	Oct. 12, 1886
The proposed location of the Massachusetts School for the Feeble-Minded, ...	Jan. 21, 1887
Boston Water Supply, ...	" " "
Alewife Brook, ...	March 8, 1887
Ware Sewerage, ...	Aug. 16, 1887
Southbridge Sewerage, ...	Sept. 6, 1887

Not the least of the duties of the Board is that of its correspondence, not only with local Boards of Health, but also with physicians and other persons desiring information relative to questions of a sanitary nature, such as the inspection of food and drugs, water supply and sewerage, the management of infectious diseases, of local nuisances, and kindred topics.

Recommendations.

1. A better organization of local boards of health in towns is needed, and the Board would therefore recommend the passage of an act such as is to be found on page lii of this report.

2. Better accommodations are needed for the various offices and laboratories now required for carrying out the provisions of the acts under which the Board is authorized to employ expert assistance.

3. The repeal or amendment of sections 103, 104 and 105 of chapter 80 relative to water returns, these sections being mainly superseded by the provisions of chapter 274 of the Acts of 1886.

Expenditures of the Board.

The following is a statement of the expenses of the Board for the year ending Oct. 1, 1887, under the provisions of the different acts under which the Board is at present carrying on its work.

In some of the items of expenses the amount stated indicates but a small portion of the amount expended in all for the purposes named, the work having been undertaken quite

late in the year, as for example, the work done at the experiment station at Lawrence, and also that included in the fitting up of the laboratory at 161 Tremont Street.

General Expenses.

For the Year Ending Oct. 1, 1887.

Appropriation,		$9,300 00
Salaries,	$4,000 00	
Printing,	1,440 99	
Stationery,	163 67	
Postage,	292 56	
Messenger,	206 73	
Special investigations,	581 99	
Extra clerical services for copying records,	350 00	
Chemical and other examinations,	491 85	
Apparatus and office fixtures,	88 19	
Incidentals,	31 02	
Travelling expenses,	459 96	
Books and binding,	168 48	
Express and telegrams,	9 75	
		$8,099 19

Expenditures under the Provisions of Chapter 274 of the Acts of 1886.

Appropriation,		$30,000 00
Salaries,	$6,747 55	
Travelling expenses,	704 09	
Maps, plans, books and binding,	196 34	
Stationery, printing, engineering and office supplies,	459 92	
Boxes, bottles and other chemical supplies,	242 81	
Expressage and telegrams,	133 84	
Chemical analyses,	190 00	
Rent of laboratory,	375 00	
Fitting up laboratory, 161 Tremont St.,	41 58	
Experiment station at Lawrence, labor and material,	1,727 01	
		$10,818 14

Expenditures under Chapter 95, Resolves of 1887.

Appropriation,		$10,000 00
Salaries,	$273 00	
Travelling expenses,	23 20	
		$296

FOOD AND DRUG INSPECTION.

Appropriation,		$10,000 00
Salaries,	$6,833 33	
Travelling expenses and purchase of samples,	1,721 18	
Legal services,	112 00	
Special analyses,	40 00	
Printing,	5 37	
Packing-boxes, bottles, materials for experimentation and incidentals,	91 74	
		$8,803 62

HENRY P. WALCOTT,
ELIJAH U. JONES,
JULIUS H. APPLETON,
THORNTON K. LOTHROP,
FRANK W. DRAPER,
HIRAM F. MILLS,
THEODORE C. BATES,
State Board of Health.

TABLE OF THERMOMETRIC EQUIVALENTS ACCORDING TO THE CENTIGRADE AND FAHRENHEIT SCALES.

Given. C. Sought. F. $n^\circ \text{ C.} = \frac{9\, n^\circ}{5} + 32$				Given. F. Sought. C. $n^\circ \text{ F.} = \frac{5\, (n^\circ - 32)}{9}$			
C.	F.	C.	F.	C.	F.	C.	F.
-17.8	0.	10.6	51.	38.3	101.	66.7	152.
-17.2	1.	11.	51.8	38.9	102.	67.	152.6
-17.	1.4	11.1	52.	39.	102.2	67.2	153.
-16.7	2.	11.7	53.	39.4	103.	67.8	154.
-16.1	3.	12.	53.6	40.	104.	68.	155.4
-16.	3.2	12.2	54.	40.6	105.	68.3	155.
-15.6	4.	12.8	55.	41.	105.8	68.9	156.
-15.	5.	13.	55.4	41.1	106.	69.	156.2
-14.4	6.	13.3	56.	41.7	107.	69.4	157.
-14.	6.8	13.9	57.	42.	107.6	70.	158.
-13.9	7.	14.	57.2	42.2	108.	70.6	159.
-13.3	8.	14.4	58.	42.8	109.	71.	159.8
-13.	8.6	15.	59.	43.	109.4	71.1	160.
-12.8	9.	15.6	60.	43.3	110.	71.7	161.
-12.2	10.	16.	60.8	43.9	111.	72.	161.6
-12.	10.4	16.1	61.	44.	111.2	72.2	162.
-11.7	11.	16.7	62.	44.4	112.	72.8	163.
-11.1	12.	17.	62.6	45.	113.	73.	163.4
-11.	12.2	17.2	63.	45.6	114.	73.3	164.
-10.6	13.	17.8	64.	46.	114.8	73.9	165.
-10.	14.	18.	64.4	46.1	115.	74.	165.2
-9.4	15.	18.3	65.	46.7	116.	74.4	166.
-9.	15.8	18.9	66.	47.	116.6	75.	167.
-8.9	16.	19.	66.2	47.2	117.	75.6	168.
-8.3	17.	19.4	67.	47.8	118.	76.	168.8
-8.	17.6	20.	68.	48	118.4	76.1	169.
-7.8	18.	20.6	69.	48.3	119.	76.7	170.
-7.2	19.	21.	69.8	48.9	120.	77.	170.6
-7.	19.4	21.1	70.	49.	120.2	77.2	171.
-6.7	20.	21.7	71.	49.4	121.	77.8	172.
-6.1	21.	22.	71.6	50.	122.	78.	172.4
-6.	21.2	22.2	72.	50.6	123.	78.3	173.
-5.6	22.	22.8	73.	51.	123.8	78.9	174.
-5.	23.	23.	73.4	51.1	124.	79.	174.2
-4.4	24.	23.3	74.	51.7	125.	79.4	175.
-4.	24.8	23.9	75.	52.	125.6	80.	176.
-3.9	25.	24.	75.2	52.2	126.	80.6	177.
-3.3	26.	24.4	76.	52.8	127.	81.	177.8
-3.	26.6	25.	77.	53.	127.4	81.1	178.
-2.8	27.	25.6	78.	53.3	128.	81.7	179.
-2.2	28.	26.	78.8	53.9	129.	82.	179.6
-2.	28.4	26.1	79.	54.	129.2	82.2	180.
-1.7	29.	26.7	80.	54.4	130.	82.8	181.
-1.1	30.	27.	80.6	55.	131.	83.	181.4
-1.	30.2	27.2	81.	55.6	132.	83.3	182.
-0.6	31.	27.8	82.	56.	132.8	83.9	183.
0.	32.	28.	82.4	56.1	133.	84.	183.2
0.6	33.	28.3	83.	56.7	134.	84.4	184.
1.	33.8	28.9	84.	57.	134.6	85.	185.
1.1	34.	29.	84.2	57.2	135.	85.6	186.
1.7	35.	29.4	85.	57.8	136.	86.	186.8
2.	35.6	30.	86.	58.	136.4	86.1	187.
2.2	36.	30.6	87.	58.3	137.	86.7	188.
2.8	37.	31.	87.8	58 9	138.	87.	188.6
3.	37.4	31.1	88.	59.	138.2	87.2	189.
3.3	38.	31.7	89.	59.4	139.	87.8	190.
3.9	39.	32.	89.6	60.	140.	88.	190.4
4.	39.2	32.2	90.	60.6	141.	88.3	191.
4.4	40.	32.8	91.	61.	141.8	88.9	192.
5.	41.	33.	91.4	61.1	142.	89.	192.2
5.6	42.	33.3	92.	61.7	143.	89.4	193.
6.	42.8	33.9	93.	62.	143.6	90.	194.
6.1	43.	34.	93.2	62.2	144.	90.6	195.
6.7	44.	34.4	94.	62.8	145.	91.	195.8
7.	44.6	35.	95.	63.	145.4	91.1	196.
7.2	45.	35.6	96.	63.3	146.	91.7	197.
7.8	46.	36.	96.8	63.9	147.	92.	197.6
8.	46.4	36.1	97.	64.	147.2	92.2	198.
8.3	47.	36.7	98.	64.4	148.	92.8	199.
8.9	48.	37.	98.6	65.	149.	93.	199.4
9.	48.2	37.2	99.	65.6	150.	93.3	200.
9.4	49.	37.8	100.	66.	150.8		
10.	50.	38.	100.4	66.1	151.	100.	212.

THE METRIC SYSTEM.

Length.

1 Myriameter,	Mm.	(10,000 m.)	=6.2137 miles.	
1 Kilometer,	Km.	(1,000 m.)	=0.62137 miles.	
1 Hectometer,	Hm.	(100 m.)	=328.0833 feet.	
1 Decameter,	Dm.	(10 m.)	=393.7 inches.	
1 Meter,	m.	(1 m.)	=39.37 inches.	
1 Decimeter,	dm.	(0.1 m.)	=3.937 inches.	
1 Centimeter,	cm.	(0.01 m.)	=0.3937 inch.	
1 Millimeter,	mm.	(0.001 m.)	=0.03937 inch.	

Surface.

1 Hectare,	Ha.	(10,000 sq. m.)	=2.471 acres.
1 Are,	a.	(100 sq. m.)	=119.6 square yards.
1 Centare,	ca.	(1 sq. m.)	=1550 square inches.

Capacity.

1 Kiloliter or Stère,	Kl. or st.	(1,000 l.)	=1.308 cubic yards,	=264.17 gallons.
1 Hectoliter,	Hl.	(100 l.)	=2 bush. and 3.35 pecks,	=26.417 gallons.
1 Decaliter,	Dl.	(10 l.)	=9.08 quarts,	=2.6417 gallons.
1 Liter,	l.	(1 l.)	=0.908 quart,	=1.0567 qts. (1.761 imperial pints).
1 Deciliter,	dl.	(0.1 l.)	=6.1022 cubic inches,	=0.845 gill.
1 Centiliter,	cl.	(0.01 l.)	=0.61022 cubic inch,	=0.338 fluid ounce.
1 Milliliter,	ml.	(0 001 l.)	=0.061 cubic inch,	=0.27 fluid drachm.

Weight.

1 Millier or Tonneau,	M. or T.	(1,000 Kg.)	=1 Kl. or 1 Cu. m.	=2204.6 pounds (avoirdupois).
1 Quintal,	Q.	(100 Kg.)	=1 Hl. or 0.1 Cu. m.	=2220.46 pounds.
1 Myriagram,	Mg.	(10 Kg.)	=1 Dl. or 10 Cu. dm.	=22.046 pounds.
1 Kilogram	Kg.	(1,000 g.)	=1 l or 1 Cu. dm.	=2.2046 pounds.
1 Hectogram,	Hg.	(100 g.)	=1 dl. or 0.1 Cu. dm.	=3.5274 ounces.
1 Decagram,	Dg.	(10 g.)	=1 cl. or 10 Cu. cm.	=0 3527 ounce.
1 Gram,	g.	(1 g.)	=1 ml. or 1 Cu. cm.	=15.432 grains.
1 Decigram,	dg.	(0.1 g.)	=0.1 ml. or 0.1 Cu. cm.	=1.5432 grains.
1 Centigram,	cg.	(0.01 g.)	=0.01 ml. or 10 Cu. mm.	=0.1543 grain.
1 Milligram,	mg.	(0.001 g.)	=0.001 ml. or 1 Cu. mm.	=0.0154 grain.

One kilogram is equal to a weight represented by one liter of distilled water at 4° C. In the centigrade scale 0 (32°+F.) is the freezing point; 100°+ (212°+F.) is the boiling point. Five degrees C. corresponds to nine degrees F.

All measures in the metric system are derived from the meter, and their names express their values. Some of the names in the French system (like our "dime") are not in practical use; e. g., hectometer, decagram, etc.

One inch=2.5 centimeters nearly; one quart (wine measure)=0.946 liter; one pound Troy=0.373 kilogram; one acre=0.4046 hectare.

WATER SUPPLY AND SEWERAGE.

WATER SUPPLY AND SEWERAGE.

REPORT OF THE STATE BOARD OF HEALTH REQUIRED BY SECTION 1 OF CHAPTER 274 OF THE ACTS OF 1886.

The work of the State Board of Health under the "Act to protect the purity of inland waters," and under the appropriation of $30,000 made by the last General Court, may be divided into three departments: —

I. That of advising cities, towns, corporations and individuals in regard to the most appropriate source of supply for their drinking waters and the best method of assuring the purity thereof and of disposing of their sewage.

II. Obtaining information in regard to all of the existing sources of domestic water supplies in the State, and subjecting samples from each source to chemical analysis once a month, and to biological examination when necessary, and in making such chemical examinations of other inland waters as the general purposes of the Act require.

III. Collecting information in regard to experiments that have hitherto been made upon the purification of sewage by applying it to land, and arranging for and conducting such additional experiments upon such purification as are necessary to obtain knowledge required for immediate use within the State.

I.

In the first department there have been twenty-five applications* from the following cities, towns and individuals for advice or official action by the Board. Of these, eleven were in regard to water supplies, as follows: Boston, Chelsea, Somerville and Everett; Bradford, Randolph and

* Blank forms of application for advice under the provisions of chapter 274 of the Acts of 1886 have been prepared for the use of cities, towns and others, and may be procured at the office of the Board at 13 Beacon Street, Boston.

Holbrook, Andover, Ayer, Belmont, North Easton, Maynard, Needham, Athol, Mansfield. There were also eleven applications in regard to sewerage: from Taunton, Milford, Ware, Westfield State Normal School, Westborough Lunatic Hospital, Clinton, Brockton, Southbridge, Athol, Reformatory Prison for Women, Waltham. Two applications in regard to pollutions of streams: Arlington, relating to pollution of Alewife Brook and Lower Mystic Pond, and Palmer, in regard to pollution of Graves Brook, and one application from W. H. Abbott, concerning the disposal of manufacturing refuse at Northampton.

To satisfactorily answer the questions submitted to the Board, under the provisions of chapter 274 of the Acts of 1886, the Board has adopted the following practice: The plans and estimates presented by the parties in interest are at once referred to the engineer of the Board, in order that he may make a careful examination of the localities concerned and determine the value of the evidence already collected. Should this be sufficient to enable him to come to a conclusion satisfactory to himself, the result is reported to the Board. The appropriate committee, and in many instances the whole Board, then visits the locality. The advice of the consulting engineer* is also obtained in all important cases; and public hearings are held whenever it seems probable that useful information can be obtained in this way.

The Board has not held it to be a part of its functions to prepare original plans, and has carefully avoided any interference with the work properly belonging to the engineers employed by the parties making application.

The responsibilities in carrying out the provisions of this Act are, as will be seen by the above statement, no less than those of the parties directly interested, nor can they be properly performed except after mature consideration, with the advice of thoroughly educated experts.

Water Supply.

The application of the Boston Water Board in behalf of the cities of Boston, Chelsea and Somerville and the town of Everett, in regard to taking the Shawsheen River as a source of supply for these communities, was presented to the

* Mr. Joseph P. Davis, C. E.

Board of Health on the 19th of January, and occupied the attention of the Board and nearly all the time of its engineer and assistants for more than two months, with careful revision by its consulting engineer. The fundamental questions of the probable growth and future needs of these communities were thoroughly investigated, and with the cordial co-operation of the Water Board of Boston, through their engineers, in supplying data in their possession, the quantity of water that can be depended upon from the present sources of supply of the city of Boston was ascertained from their latest surveys and complete records; and the comparative cost of future maintenance of the supply to these communities from the different sources was determined. It was concluded by the Board of Health that it was not only for the interest of all parties holding property within the valley of the Shawsheen River, but also largely for the interest of the city of Boston and the communities associated in her application, that the present sources of supply controlled by the city of Boston were and would be for many years the most appropriate source of supply for these communities, and on the 6th of April the following communication was made to the Boston Water Board: —

State Board of Health, 13 Beacon Street,
Boston, April 6, 1887.

Col. Horace T. Rockwell, *Chairman of the Boston Water Board.*

Dear Sir: — The State Board of Health has had in careful consideration the scheme of taking water from the Shawsheen River for the use of the cities of Boston, Chelsea and Somerville, and the town of Everett, which you, in their behalf, presented on the 19th of January in accordance with chapter 274 of the Acts of 1886.

The purpose of this Act bearing upon the proposed scheme is, that this Board shall consult with and advise you whether this is the most appropriate source of supply, having regard to the interests of all who may be affected thereby.

In considering this question we have made a careful investigation of the present and future needs of the communities which you represent, and the amount of water which can be depended upon from the sources of supply which have by the State been put under your control.

The conclusions already reached, differing in some respects from

those presented by you, have so important a bearing upon the general consideration of the subject that we now present them as the basis for further consideration.

From a careful study of the experience of Boston and other places made by our chief engineer (the details of which upon this point or upon others which may arise he will, if you desire, explain to you or to your engineer), he reaches the conclusions, which we regard reasonable and well founded, that with careful and business-like restriction of waste the consumption of water within the district supplied by Boston in 1895 may be reduced to 66 gallons per inhabitant; and to provide for the increasing yearly use for the next forty years four-tenths of a gallon per year should be added to 66 gallons for the quantity to be supplied for each succeeding year, making the estimated consumption of water per inhabitant in this district as follows: —

1895, ...	66 gals. per inhabitant.
1900, ...	68 " " "
1905, ...	70 " " "
1910, ...	72 " " "
1915, ...	74 " " "
1920, ...	76 " " "
1925, ...	78 " " "
1930, ...	80 " " "

The population of the district now supplied with water from the Boston Works has been as follows since 1840: —

YEAR	Population.	Increase in Five Years.
1840, ...	122,646	–
1845, ...	157,836	35,190
1850, ...	193,027	35,191
1855, ...	232,663	39,636
1860, ...	268,916	36,253
1865, ...	292,382	23,466
1870, ...	327,951	35,569
1875, ...	388,175	60,224
1880, ...	413,713	25,538
1885, ...	451,898	38,185

From a careful study of the growth of the whole district and of its several parts, we find it reasonable to conclude that the future growth will be nearly as follows: —

YEAR.	Population.	Increase in Five Years.
1890, ...	493,100	41,202
1895, ...	534,900	41,800
1900, ...	577,300	42,400
1905, ...	620,300	43,000
1910, ...	663,800	43,500
1915, ...	707,900	44,100
1920, ...	752,600	44,700
1925, ...	797,900	45,300
1930, ...	843,800	45,900

The sources of supply now used for this district are Cochituate Lake, Sudbury River and Mystic Lake. The latter drains an area which has a population of about 800 per square mile. The amount and present rapid increase of this population, together with the character of the refuse from many manufacturing establishments, indicates the probable necessity of the future abandonment of this source of supply, and we confine our consideration to the Cochituate Lake and Sudbury River sources. The quantity of water which can be depended upon from these two sources, when all of the storage basins which the city of Boston proposes to build are completed, has been the subject of careful study by our engineer, based upon the quantity that was derivable in the series of years 1880 to 1883, when the yield of the streams was very much lower than ever before known, with the results of a net daily yield from these sources of 56,000,000 gallons during the driest year.

From this quantity there is to be deducted 1,500,000 gallons, which the law requires should be allowed to run down the river daily; 2,700,000 gallons daily which the towns upon the Sudbury and Cochituate watersheds will, it is estimated, have the right to draw from these sources, and deducting also 1,800,000 gallons for unforeseen contingencies, we have 50,000,000 gallons available daily, during the driest year, for the use of the city of Boston. This quantity will be sufficient to supply the estimated population

of Boston, Chelsea, Somerville and Everett with 72.8 gallons per inhabitant until 1912, and will supply the estimated population of the present territory of the city of Boston with 80 gallons per day per inhabitant until 1925. Having reached these results from a careful consideration of the actual existing conditions, this Board is constrained to advise that the most appropriate source of supply for a term of years for the district which you represent is the territory already under the control of the city of Boston in the Cochituate and Sudbury River areas. If these, our conclusions, are borne out by the experience of Boston, Chelsea, Somerville and Everett, although the Mystic be abandoned, the city of Boston can from the other sources under its control supply these communities, and need not, for quantity of water, seek a new source for fifteen years at least, and then there will be ten years for construction of works before the additional quantity will be needed.

We would add that, from such examination as we have been able to make, pecuniary considerations are in the opinion of the Board largely in favor of the development of the Cochituate and Sudbury River sources to their full extent before introducing a new source. By order of the Board,

SAMUEL W. ABBOTT, *Secretary.*

BRADFORD. — The selectmen of Bradford, by letter dated Feb. 2, 1887, asked the advice of this Board with reference to two ponds which they thought might be suitable as a source of water supply. These were Johnson's Pond in the towns of Groveland and Boxford, and Mitchell's, or Hovey's Pond, in the latter town. The ponds were examined by our engineer and samples of their waters were taken for analysis; but the time of taking the samples being that of high water from spring rains they were not regarded as conclusive. The Board replied on March 2 that —

While no evidence is presented by such examinations that the quality of the water, either of Johnson's or of Mitchell's ponds, is at this time objectionable, the Board is unable without further examination, which would extend until after your March town meeting, to give a definite judgment as to the appropriateness of these ponds for your water supply.

RANDOLPH AND HOLBROOK. — The joint boards of Water Commissioners of these towns, on the 23d of February, sub-

mitted their plans for taking the water of Great Pond, lying partly in Randolph and partly in Braintree, for a joint water supply. It was proposed to pump the water into iron water towers, one to be situated in each of the towns to be supplied.

After carefully examining the surrounding country to see if some of the objections to this source could not be avoided, the following advice was given : —

The State Board of Health has by its engineers examined the available sources of water supply for the towns of Randolph and Holbrook, and considering their present population and probable growth has been unable to find a more appropriate source of supply than the proposed source, — Great Pond in Randolph and Braintree. This source has, however, unfavorable characteristics which demand attention. Upon its watershed live about one quarter of the inhabitants of Randolph, nearly 1,000 people, whose sewage should be kept out of the pond. From about one-half of these houses the sewage can at reasonable expense be turned into the watershed in the south-easterly part of the town and be disposed of with the sewage from that quarter. The remaining sewage in the drainage area of the pond should be effectually filtered, or otherwise purified, so that it will not be detrimental to health before being turned into the pond or into any of its tributaries.

Andover. — The committee on water supply of this town notified the Board that a petition had been presented to the Legislature of 1886 for authority to take a water supply from any source within the limits of the town, and that the petition had been referred, by that body, to the Legislature of 1887, where it was then pending. The large number of cases relating to water supply and sewerage having precedence of this one prevented its consideration until the action of the Legislature, in granting the petition, made it unnecessary for this Board to act until the question should come to them in more definite form.

Ayer. — The Water Commissioners of this town, June 20, 1887, asked the advice of this Board as to two proposed sources of water supply. They also asked if *subsoil* waters had been found more satisfactory throughout the State than *pond* waters. The sources submitted were

Sandy Pond, said to have an area of about seventy-five acres, and a proposed well near a mill-pond. The advice contained in the reply of the Board, given below, with regard to storing waters *collected from the ground* in dark, covered reservoirs, was based largely upon the experience of cities and towns in this State, which was at that time being gathered in connection with the systematic examination of all of the public water supplies. Further returns received, and the result of chemical and biological examinations since made, emphasize the need of following this advice: —

In response to your request to know whether subsoil waters have been found more satisfactory than pond waters we give you a summary of results reported to the Board up to the present. Of seven places which collect ground water and store it in open earthen and masonry reservoirs, three report trouble, and four report no trouble. Of fourteen places so collecting and pumping into iron or masonry tanks, some of them covered, two report trouble, one which shows by analysis to be poor before being stored, and twelve places report no trouble. The surface water supplies, including both ponds and storage reservoirs, have given more trouble east of the Connecticut River than west of it in the mountainous region. Up to the present time the ground water supplies have given less trouble than surface water supplies, and the ground water supplies are far more satisfactory when used directly after being drawn or with as little storage as practicable.

The samples of water submitted from both of the sources of supply are of satisfactory quality; that from the flowing well is unusually satisfactory. The information furnished is not sufficient for determining whether a sufficient quantity can be obtained from the proposed wells or not. If assured of the necessary quantity the Board would advise adopting the supply from wells, and to avoid deterioration when stored in open reservoirs such water as cannot be conveyed directly from the wells to the consumers should be stored in a dark, covered reservoir, made as small as practicable. A second and larger reservoir may be necessary as a resource in case of fire or other emergency.

BELMONT. — The Water Commissioners, on the 28th of June, 1887, gave notice of their intention to take water from the Watertown Water Supply Company. The proposed source being an established water supply which had

been examined by the Board and found of suitable quality, notice to this effect was sent to the Commissioners.

North Easton. — The Board of Water Commissioners in July submitted outlines of proposed plans of water supply for the village of North Easton. It was proposed to collect a supply of ground water from a well to be sunk in a meadow not far from one of the mill-ponds on the Queset River.

The matter was examined and the source which they had selected approved, with the further advice that in case of insufficient quantity an additional supply should be sought from underground sources and connected with the proposed system without exposure to light.

Maynard. — In the application presented to this Board, August 15, 1887, by the committee on water supply of the town of Maynard, the statement is made that the committee are authorized to investigate the question of water supply for the town, and to petition the Legislature, to be convened in 1888, for permission to take the waters of White Pond, situated in the towns of Hudson and Stow about two and one-half miles south-west of the site of a proposed pumping station in the town of Maynard. The committee asked the advice of this Board as to the most appropriate source of supply for the town, and particularly as to the source selected by them. This source has been examined by our chief engineer, and an analysis of the water has been made. The sufficiency of the supply as regards quantity is not so obvious that it can be determined from such examinations as we think it practicable for our engineer to make, and the committee have been asked to employ an engineer to make surveys and furnish more definite information upon this point.

Needham. — The water committee of this town asked the advice of the Board in regard to two sources for the supply of ground water, which they had been investigating. The Board advised that the danger of pollution within the Rosemary Valley was so great that this source should be rejected; also, for the same reason, water should not be

taken from that portion of the valley containing Colburn spring, west of Dedham Avenue.

The area east of Dedham Avenue appears suitable at present, but may not continue of satisfactory quality with the growth of the town, and the Board advised further examination for a filter gallery on the bank of Charles River, to be used in connection with this supply or distinct from it.

Athol. — In the application presented to this Board by communication dated Nov. 18, 1887, the statement is made that the town has voted to petition the next Legislature for the right to take water, for domestic and other purposes, from Phillipston Pond in the town of Phillipston.

The committee of the town of Athol who have this matter in charge ask the opinion of this Board as to whether this pond will furnish a sufficient quantity of water of good quality to supply the town in years to come. The proposed source and others in the vicinity of Athol have been examined by our engineer and the matter is now under advisement.

Mansfield. — The Board of Water Commissioners of the Mansfield Water Supply District on the 12th of December, 1887, gave notice to this Board of their intention to introduce a system of water supply, and submitted outlines of their proposed plans. The investigations in this case have not yet been made.

Advice in Regard to Disposal of Sewage.

Taunton. — On Dec. 13, 1886, the Sewerage Commission of this city submitted a report containing their conclusions as to the best method of disposing of the sewage of the city.

Briefly stated, they report that Mill River, which at present receives the sewage of the city and the drainage from gas works, etc., is at times offensive, and that, to prevent offence, it is desirable to straighten and wall the stream, to make the bottom concave, to remove the lower dams, and to obtain the control of the water of one or more mill privileges for the purpose of flushing; with these things carried

out, they believe the river can carry the sewage of the city for a long time to come.

On Feb. 4, 1887, the Board sent the following reply: —

That from the reports of its engineers of the results of their examination of the ground which was visited in company with the Sewage Commission of the city, this Board does not approve of the proposed system of sewage disposal for the city of Taunton.

MILFORD. — The town of Milford, through their engineer, Mr. Ernest W. Bowditch, submitted plans for the disposal of the sewage of the town by filtration through land, the effluent from the filter beds to go into the Charles River. Mr. Bowditch appeared before a committee of the Board and explained the proposed scheme. After due consideration the Board replied that —

In their opinion it is not desirable to locate a filtration ground on the banks of a stream which supplies water for domestic use, and as Milford is upon such a stream, but also adjacent to a drainage area not so used, the Board suggests that examination be made to determine whether a suitable filtration ground may not be found in the drainage area not used for a domestic water supply. If, however, the filtration ground must be located in the drainage area used for a domestic water supply, it is regarded as undesirable to have its effluent discharge directly into the river, and preferable to select a ground which is distant from the river, that any effluent from the ground not properly filtered may be recognized, and prevented from entering the river.

WARE. — The Road Commissioners submitted to the Board, March 19, 1887, two plans made by different engineers for the sewerage of the town. Both plans proposed to discharge the sewage into the Ware River. The Board advised the town to have plans prepared for a system of sewerage providing for the separate removal of sewage and storm-water, and to have the cost estimated for comparison with the cost of the system proposed by the present plans.

In the latter part of July an outline of a proposed system of sewerage, in which storm-water and sewage are to be kept separate, was submitted to the Board. After giving a hear-

ing to the town and to others interested, the Board gave the following advice : —

The State Board of Health having given a hearing to the town of Ware and others interested in the disposal of its sewage, and having considered the plan of sewerage presented, renew their recommendation that the separate system of sewerage be adopted in order that, should it prove necessary in the future to purify the sewage before turning it into the river, it can be done with reasonable expense.

With such system, and the understanding that the turning of crude sewage into the river may in time prove detrimental to the needs and interests of this or other communities, and it will then be otherwise disposed of, the Board approves of the general method of disposal presented.

In regard to advice asked upon details of the system to be adopted, the Board finds the plan presented so incomplete that it cannot serve as a basis for such advice.

The economy and efficiency of a separate system of sewerage depend so much upon the proportion of parts to the work required of them, and the design and arrangement of details, that much more study should be expended upon these subjects than the present plans indicate.

The plans should comprise a general plan, with drainage districts shown upon it, profiles of each street showing sewers with sizes and grades, and the locations of all cellars in the business portions, or in other places where they may be difficult to drain. The plans and profiles should also show the location of manholes and flushing chambers. Details should be made showing designs of brick sewers, manholes, flushing chambers, catch basins, etc., and of the river outlets and works to protect them.

A report should be made by the engineer, describing the system and how it is to be operated, and giving the estimated cost of the whole system, and of such a portion of it as would be desirable to build at first.

Upon receiving such plans the officers of the Board will examine and advise if any changes are desirable.

State Normal School at Westfield. — The following letter contains a statement of the condition of the drainage at the State Normal School at Westfield, indicated in the application of the Committee on Education of the Legislature, together with the advice of the Board relative to the same : —

To the Chairman of the Committee on Education.

Dear Sir: — The State Board of Health received from Mr. Foote, the secretary of the committee on education, a plan of a proposed sewer in School Street, Westfield, —with the proposed Act, House Document No. 195, — with the request from said committee that the State Board of Health would examine and report to the committee if the plan proposed be the best method of relieving the State Normal School and Boarding Hall of the ill effects which they experience from the present condition of drainage in their vicinity. The method proposed is to build a two feet by three feet brick sewer through School Street, from where the town brook crosses this street to the south side, to where it re-crosses to the north side, a distance of some 700 feet, turn the brook through this sewer and cut off all that part of the brook which lies south of School Street, and then drain the State buildings into the sewer. The most important objects affecting the State property being to remove the unwholesome brook with open walls, now used as a sewer, which runs directly under the cellar of the Normal School Boarding Hall and to drain the two State buildings. The State Board of Health has examined this matter by its committees and by its engineer, and while other plans for accomplishing the desired result at the State buildings, such as replacing the open walls of the brook through the lot of the Boarding Hall by a thirty inch iron pipe with tight joints and a sufficient pipe sewer from the school building down School Street to the brook, have presented some advantages over the one proposed in the bill, the Board has upon further consideration been obliged to conclude that neither of these methods presents an adequate or permanent relief to the State buildings and the territory adjacent and along the valley of this brook. This brook extends for a third of a mile below the proposed sewer as a sluggish ditch winding through barnyards, and under buildings, much obstructed by sewage débris, the flow from adjacent privies and from street and yard surfaces, and is the general receptacle of anything which people wish to get rid of; the walls are falling in and are being crowded nearer together by frost; the bottom is filled with one foot or more of decaying material which upon being stirred sends up foul gases. It will be evident upon consideration that a sewer seven hundred feet long, replacing eight or nine hundred feet in length of such a brook, in which distance the fall in the brook is about one foot, will not in its middle section reduce to an appreciable extent the level of water standing in the ground adjacent, and in time of heavy rain upon the 314 acres drained by this brook above Washington

Street the cellars which have been flooded by this brook are still to be flooded; and the small culverts up the stream which now hold this water back in ponds after heavy rains will naturally be enlarged from time to time, bringing the water down the valley after a rain more freely and causing increased flooding of cellars.

The large drainage area of 314 acres (nearly one-half a square mile) above Washington Street cannot, in such rains as we have had and are liable to have every few years, be drained by a sewer two feet by three feet, nor by a brook like Town Brook, without overflowing its banks. It is as impossible as it was in 1878 for the Westfield River with its drainage area of 350 square miles to discharge its 53,000 cubic feet of water per second by its river channel without overflowing its banks. To prevent such an overflow the people of Westfield have enlarged the opening at this dam and increased the area of the river channel by building a long and high dike. At Town Brook the same principles must be employed by a different method. The sewer must be made larger, be placed at a lower level and discharged farther down the valley.

A thirty-inch pipe with lead joints could be put in place of the stoned brook through the premises of the Boarding Hall, and the Normal School be drained down School Street to the brook for about half the cost of the sewer proposed by the bill in School Street, and the buildings be as well provided as with that sewer; but neither plan will in the opinion of this Board give adequate and permament relief. Such relief can be obtained by building a sewer four feet in diameter from where the brook first crosses School Street, west from the Boarding Hall, at a lower level, in which water will have its surface in the different stages, three feet lower than at present. This sewer should be continued down School Street to Elm Street, across Elm and down Main Street to the brook at the Riding Park. Here the sewage and brook water could be turned into Town Brook for the present, but if the water now coming from the canal be cut off, or if, in future, a large amount of sewage be brought down this main sewer in Main Street, it would be necessary then to have at the Riding Park an overfall to discharge storm water directly into Town Brook and continue a smaller sewer, about two feet in diameter, large enough to convey the ordinary sewage down Main Street to the river.

The town of Westfield had an investigation made fourteen years ago and a plan proposed for main sewers in Elm Street and in Main Street. The School Street district by that plan was to drain through the northern part of Elm Street to the river a little below the dam; but there is to this plan this serious objection, which has been brought to notice since the plan was proposed.

The water below the dam, near the outlet then proposed, stood in the great freshet of 1878 at the height of 87.8 feet, and should such a freshet again come the water here would flow back through the sewer into the cellars of a large section of the town, including those of School Street; but at the outlet now proposed near the Riding Park the water of the great freshet stood at the height of 82.7 feet or five feet lower than below the dam, and would consequently flow back to so much less height in cellars; and farther, the increased fall in the shorter distance enables this main sewer to be much smaller than an equally efficient one would be, discharging near the dam.

The engineer of the Board has made an estimate of the cost of such a sewer, which is upon a more liberal basis than the estimates made for the town fourteen years ago and is intended to cover fully all that it would cost to build the sewer at this time, provided no ledge be encountered. This estimate for the sewer four feet in diameter, with its manholes and entrances from where the Town Brook first reaches School Street west of the Boarding Hall to the Town Brook at the Riding Park, amounts to $32,000.

It is the opinion of the Board that such a sewer, shown upon the accompanying plans, should be built by the town of Westfield for the preservation of the health of its residents; and it would in the judgment of the Board be much better for the State to pay the town a liberal assessment towards the building of such a sewer with a branch along Washington Street to the Boarding Hall than for the State to spend the amount proposed in accordance with Bill No. 195, with the inevitable result of neither adequate nor permanent relief. The principal of the school very properly objects to delay in removing the brook from under the Boarding Hall, on account of injury to the inmates and the knowledge of probable injury deterring others from coming to the school. This may be overcome during the necessary time of construction of the sewer by leaving two cellar windows open and from an opposite quarter of the cellar, putting up a wooden flue 18 inches square against the outside of the house, connecting it freely with the upper air in the cellar and producing in it an artificial draught by means of a fan or by a group of burning gas jets sufficient to change the air frequently in the whole cellar.

WESTBOROUGH LUNATIC HOSPITAL. — On the 8th of April the trustees of the hospital requested the Board, among other things, to examine the system of sewage dis-

posal at the hospital and recommend a proper disposal of the sewage.

In a communication to the trustees dated May 9th, treating principally of the condition of the buildings, and advice in regard to them, the Board made the following statement in regard to disposal of their sewage: — *

The present method of disposal of sewage after leaving the hospital is to convey it across the main road to the orchard and let it run on the surface down the hill in the watershed of the Sudbury River, where it forms a small contribution to the water supply of the city of Boston. This method of disposal cannot, of course, be allowed to continue.

There is in this field perhaps fifteen acres, so situated that the sewage could be applied to it advantageously, and under proper management this could be allowed to be done during the months of rapid growth of the crops; but during six months of the year, at least, the sewage should be withheld from this area and taken in an iron pipe to a tract of land over the brook running from Chauncy Pond to Little Chauncy Pond, the drainage from which land is not used for a water supply.

The details of the arrangement of irrigating ditches on these two tracts can be decided after surveys are made giving contour lines at every foot in height, and locating trees and other obstacles to ditching to be avoided. The tract of land over the brook, owned by the hospital, does not appear from an examination to have so many natural advantages for purifying sewage as the twenty-eight acre tract next beyond, which we were told could be bought for a moderate price; and the choice would be determined by the more detailed examination of your engineer designing the arrangement of your irrigation field.

In October, 1887, the trustees of the hospital, through their engineer, submitted a plan proposing a subsoil distribution of the sewage upon a tract of land on the side hill, north of the hospital and outside of the watershed of Sudbury River, so that the effluent would not run into any water used for a domestic supply.

The engineer of the trustees appeared before a committee of the Board Nov. 3, 1887, and explained the nature of the ground upon which he proposed to dispose of the sewage

* The remainder of the letter relative to other sanitary conditions at the Hospital may be found in the General Report. (Public Institutions.)

of the hospital and the general features of the plan. From his account the material proved, by trial pits, to be so much better adapted to the filtration of sewage than inspection of its surface promised, that the Board advised the trustees that it saw no reason to doubt that the sewage of the hospital can be disposed of upon that tract without risk to the health of its inmates or to the public. The details of the method of distribution were not submitted, and the Board consequently expressed no opinion upon the subject.

Clinton. — The Board of Road Commissioners submitted a plan for the sewerage of the town to this Board for advice. It was proposed, generally, to take storm water and sewage together in the same sewers to an intercepting sewer in the valley of Coachlace Brook. This sewer was intended to carry but little more than the dry weather flow of sewage, overflows being provided for the discharge of all excess during storms. The plan provided for carrying the sewage to the bank of the south branch of the Nashua River, but left the question of its final disposal in abeyance. After careful examination of the subject by its engineers, and giving a hearing to all interested, the Board gave the following advice: —

The State Board of Health has by its engineers examined the question presented by the town of Clinton, and advises that the sewage of the town be separated from its storm water, and that the sewage be purified either by intermittent filtration upon land, or by chemical precipitation, or by a combination of the two processes, before being turned into the river.

At the height proposed for the outlet of the main sewer, the sewage for nearly the whole of the present town can be conveyed without pumping to land upon which it may be purified by intermittent filtration; and if the town grows to such an extent that this area becomes insufficient, it can still be used for filtering the night sewage, and the day sewage can be pumped to higher land near, which appears well adapted for the purpose. The height of the outlet would also admit of clarification of the sewage by chemical precipitation.

The town should have the matter of the purification of its sewage carefully examined, and plans therefor, by the best method, prepared by an engineer competent to do such work.

Any data which the chief engineer of the Board may have, which will be of service to the town in such investigation will be at your disposal.

Brockton. — The question of the disposal of the sewage of this city was brought before the Board in February, 1887, while the petition of the city with reference to the same subject was pending in the Legislature. A bill having been there framed, which, if enacted, required subsequent action by this Board before the scheme of sewage disposal contemplated could be carried out, the city authorities did not desire further action at that time.

In July, 1887, no final action having been taken by the Legislature, the joint standing committee on sewerage and drainage of the city of Brockton gave further notice to this Board of their intention to introduce a system of sewerage, and submitted outlines of proposed plans, and asked the Board to consult with and advise them as to the best practicable method of disposing of their sewage. The Board have by themselves and by their engineers, with the assistance of the engineers employed by the city, carefully investigated the different plans which have been proposed, and on Oct. 31, 1887, they gave a hearing at Brockton to all parties interested. The Board to the present time has made only the preliminary report given below, the more detailed report being delayed that the Board might be guided in its advice by the experiments on the disposal of sewage now being carried on by them at the Lawrence Experimental Station.

In response to an application from the city of Brockton to the State Board of Health for advice as to the best practicable method of disposing of the sewage of Brockton, the Board will in future make a more detailed report, but for your immediate use state the following conclusions: that the method of purification by intermittent filtration upon land is best adapted to your circumstances, and that the muster field area, partly in Brockton, partly in Easton and partly in West Bridgewater, is the best adapted for a filtration area for the purification of such sewage, affording abundant area for the future growth of the city.

The Board also finds that the part of this area within the city

of Brockton, together with other land near to, and easterly therefrom, which is not so favorable for the same purpose, forms an area within the limits of the city which for several years will be adequate for the purification of the sewage of Brockton.

Southbridge. — The special committee on sewerage of the town of Southbridge, in July, submitted plans for the disposal of the sewage from a portion of the town, in connection with the improvement of the channel of a polluted brook passing through the thickly settled part of the main village. After the matter had been investigated and a hearing had been given to those interested at the rooms of the Board, the following reply was made : —

The Board of Health is not prepared to advise the town of Southbridge to dispose of its sewage in the way proposed by the plans presented. It may not be many years before the town will be required to purify its sewage before discharging it into the river, and the Board advises that before adopting any plan to relieve a locality, a study should be made of a means of conveying the sewage proper of the whole town, separate from storm water or ground water, to a place where it can be pumped to a filtering area and be purified before being turned into the river. Such study and plans being made, it will then be for the Board to decide whether the sewage may temporarily be turned into the river.

By proceeding in this way the Board sees that much expense is likely to be saved by the town in redesigning and rebuilding works unsuited to the work to be required of them.

Such information as may have been obtained by the State Board of Health upon the subject of sewage disposal in general, and with special reference to the conditions existing at Southbridge, will be placed at the disposal of the authorities of your town at the office of the Board.

Athol. — The sewerage committee of Athol, Aug. 29, 1887, submitted plans for the sewerage of the town, which proposed the discharge of the sewage into Miller's River, below the lower village, and asked this Board as to their right to so discharge it. The Board replied as follows : —

So long as the river is used as a supply for drinking water at Orange, Athol is, by chapter 80, section 96 of the Public Statutes,

prohibited from discharging sewage into the river. The sewage may be purified by filtration through land, so that the effluent may be turned into the river. From an examination made by the engineer of the Board there appears to be land near the Fitchburg railroad, about one and a quarter miles below the proposed outlet, to which the sewage may be pumped, that is suitable for filtration purposes, and it is possible that other suitable area may be found to which it may be conveyed by gravity. The Board advises the town of Athol to have examination made by a competent engineer to determine the most economical method of disposal upon a suitable filtration area, for which purpose the engineer of the Board will give the engineer of the town any data in the possession of the Board that may be of service.

Sherborn Reformatory Prison for Women. — The Commissioners of Prisons, Oct. 10, 1887, asked the advice of this Board in regard to supplementing the present sewage-disposal area by the addition of some land, easterly and across the road from the prison; also, whether the pipe, conveying sewage from the present sewage-tanks to this land, could be carried under the basement of one portion of the building without detriment to the health of the inmates.

The Board, in their reply, suggested some modifications of the plan proposed, and that the pipe passing under the building, and for not less than twelve feet outside of it, should be of cast-iron of the kind used for water-supply in cities, to be connected with tight lead joints. The reply ended with the advice that in the opinion of the Board a pipe sewer constructed of iron as above described, below the basement of the prison building, would not injure the health of the occupants of the prison.

They do not consider the proposed irrigation field east of the prison essential to the general plan of sewage disposal; and they are not prepared to say that the profit from the use of sewage irrigation, as an assistance to the farming operations of the establishment, would yield fair return upon the money thus spent.

Waltham. — The Sewerage and Drainage Commissioners of Waltham, in submitting their scheme for sewage disposal, make the following statement to this Board: —

The Sewerage and Drainage Commissioners of the city of Waltham were ordered by the city council last year to report a system of sewage disposal for our city.

We reported in favor of the system recommended by the State Commissioners, namely: the building of a trunk line of sewer down the valley of Charles River to Boston; to be constructed and maintained by the several cities and towns using it.

Since the action of the Legislature last winter, postponing action on the State Commissioners' report, we have been considering other methods of disposal, and particularly the system of *clarification by the use of precipitants*, and then discharging the effluent into Charles River, and it is with reference to this method of disposal that your advice is particularly desired.

After giving a hearing to the town, the Board sent the following: —

The Board is not prepared to advise the city of Waltham to adopt the plan proposed: to clarify the sewage by chemical precipitation, and discharge the effluent into the Charles River. The general subject of the drainage of the Mystic valley, and so much of the Charles River valley as may be drained with it, has been submitted to this Board by the General Court with instructions to report, one year from this time. Until this examination is completed, the Board will not be in condition to make definite recommendations; but the Board, as at present advised, sees no solution of the question of the sewage disposal of the city of Waltham so satisfactory as some method of conveying it to the deep sea at Moon Island, in conjunction with the city of Newton, and the town of Brookline and the Brighton District of Boston.

Pollution of Inland Waters.

Arlington. — The selectmen and Board of Health of the town of Arlington, on the 14th of February, 1887, presented a communication to this Board representing that Alewife Brook, forming the boundary line between Cambridge and Arlington, received a large quantity of sewage from three Cambridge sewers, and much offensive matter from the slaughter-house of Niles Brothers; that the waters of said brook are at all times contaminated and polluted, and that they constantly endanger and imperil the public health.

These authorities of the town, therefore, requested this Board to take such action in the premises as may be author

ized by law to prevent the pollution of the waters of said brook.

A hearing was given March 8, 1887, to the Arlington authorities and other parties interested.

On the 9th of July, 1887, a second communication was received from these same authorities requesting this Board to cause examinations to be made of the waters of Alewife Brook, and of the Lower Mystic Lake, for the purpose of ascertaining whether the same are in a condition likely to impair the interests of the public or imperil the public health. In addition to this request the communication contained substantially the same representation and request as the first one.

The Board caused examination to be made in July and August with the result that they found Alewife Brook polluted to such an extent that it has ceased to be a brook and has become a sewer, and below the entrance of the drain from Niles' slaughter house is much more offensive than ordinary city sewers. Its condition improves somewhat before reaching Mystic River.

The public health requires that such an open sewer should not exist, and the means of relieving the public of this nuisance are a part of the problem of disposal of the Mystic River sewage, which the Legislature has referred to this Board and which is now being actively considered.

On the days when the lower Mystic Lake was visited there was no noticeable odor except in the immediate vicinity of the place where the discharge from the Mystic Valley sewer enters the pond. Chemical examinations, however, show that the waters are polluted, as may be seen by the following analysis of water taken from the surface in the middle of the upper half of the lake, on July 27, 1887, expressed in parts in 100,000 : —

Total residue,	241.50
Loss of residue on ignition,	32.40
Fixed residue,	209.10
Free ammonia,	0.0578
Albuminoid ammonia,	0.0506
Chlorine,	127.0
Nitrogen as nitrates and nitrites	Present

PALMER. — People living along Graves Brook in this town made complaint to the Board that the waters of the brook had become polluted by the filth coming from a carpet mill, including both the manufacturing refuse or drainage and the washings from privy vaults, to such an extent as to make the waters foul and offensive, and to imperil the public health. The circumstances were examined and the following response made on December 7 : —

Section 96 of chapter 80 of the Public Statutes provides that "no human excrement shall be discharged into any stream used as a source of water supply by a town within twenty miles above the point where such supply is taken, or into any feeders of such stream within such twenty miles."

Water being used from the river at Chicopee Falls for domestic purposes within twenty miles from the carpet mill at Palmer, this mill and all others in the vicinity are prohibited from discharging their privies into the stream. As to the further discharge from the carpet mill the State Board of Health does not see that in the case as stated by you they have authority to interfere.

DISPOSAL OF MANUFACTURING DRAINAGE OR REFUSE.

NORTHAMPTON. — On the 3d of December, 1887, an application was made to this Board for advice with reference to the disposal of the drainage from proposed soap works to be built in Northampton. The Board caused examinations of the locality to be made by its secretary and appointed a time for a public hearing, when the application was withdrawn on account of the failure to procure the desired land for the works.

II.

The following observations pertain to the operations of the Board referred to in the second department of work.*

The Board of Health has at various times called attention to the limitations of the methods hitherto practised for determining the character of the substances present in water, which may have an injurious effect upon human health.

It was therefore decided to call to the assistance of the Board some analytical chemist of the highest repute, who should be directed not only to repeat such examinations as have heretofore from time to time been made, but also to again critically examine the successive steps of such examinations with a view to their possible improvement and extension.

We believe that at the end of a year's work we can point to improved methods of analysis, and that we shall then be in condition to give a more exact interpretation of results.

Prof. T. M. Drown of the Massachusetts Institute of Technology has had charge of the chemical analyses. Mrs. R. H. Richards has had the immediate oversight of the laboratory staff, consisting of Messrs. A. H. Gill, Henry Martin, H. A. Richardson and Miss Isabel F. Hyams. Regular work was begun in June, 1887, and there have been examined 1,509 samples of water. In accordance with the general plan, as above stated, a great deal of work has been done in studying the changes which waters undergo in different conditions, and in perfecting analytical processes in the line of greater accuracy and rapidity.

We have thought it advisable to withhold a general discussion of the analyses already made until we have in our possession observations extending through all the seasons of the year.

The chemical examinations of the water supplies have been accompanied so far as possible by a study of the animal and vegetable life always present to a greater or less degree in surface waters.

Mr. G. H. Parker, S.B., assistant in Zoölogy in Harvard

* See page 2.

University, has had charge of the examinations of waters with reference to the forms of vegetable and animal life which are either evident to the naked eye or which can be studied with the lower powers of the microscope. To E. K. Dunham, M.D., was assigned the investigation of the bacteria and kindred forms of vegetable life, which can only be studied with the higher powers of the microscope, and by various elaborate methods of cultivation, requiring much time and great technical skill.

Mr. Parker began his work in July. Dr. Dunham entered upon his investigations in October. It is too early, therefore, to attempt to draw many very definite conclusions from their observations in their respective fields of inquiry.

The details of a plan for procuring samples of water from the various supplies under consideration, so accurately defined as to permit of comparison with samples taken from the same sources throughout the year or in any succeeding year, have been carefully prepared by the chief engineer of the Board, F. P. Stearns, C. E.

Preliminary to this work all the statistical information which could be obtained was brought together and so arranged that all the recorded facts concerning any public water supply were made available. We can therefore compare with more confidence than ever before our successive observations of the water supplies of the State.

All the important details relating to this subject will be found in the report of Mr. Stearns hereto appended, together with a very instructive discussion of some of the results obtained.

It will be seen that municipalties representing eighty-two per cent. of the whole population of the State are provided with public water supplies, — a sufficient argument for treating this question with a consideration due to one of our most important sanitary problems, and with the certainty, moreover, that the difficultes of the situation will increase from day to day. Some observations upon the composition of water in filter galleries by the side of streams and ponds will also be found in this Appendix, to which attention is also called. They have great practical value in demonstra-

ting some of the advantages of this method of collecting potable waters.

As only a limited number of water supplies could be examined by Mr. Parker and Dr. Dunham, it was thought wise to begin with the largest and most important supplies, first on account of the great number of people dependent upon them, and secondly, because all their physical conditions were much better known, and because more information could be had without expense to the State. From time to time other water supplies have been examined in this exhaustive manner, as occasion has seemed to require.

Three classes of plants are found in our ponds and reservoirs. First, those which are fixed in the basins, such as the common pond weeds and a few filamentous algæ. Second, those which are suspended in the water, but do not readily decompose, including the common green algæ (*desmids*, *diatoms*, etc.) and duck-weeds. Third, those which are suspended in the water and readily decompose, the blue-green algæ (*Cœlosphœrium*, *Anabœna*, and *Clathrocystis*).

Plants firmly fixed in streams and basins are harmful mainly in affording a lodging-place for the development of plants belonging to the groups two and three above noted. In basins having much fluctuation of level, plants of the first group may injure the water by their death and consequent decay.

The floating plants of the second group are injurious, since, after a long carriage through a closed conduit or in continued hot weather, they die and decompose. In Boston water, taken from a tap, they are usually dead; in Cambridge they are usually alive in the water taken in the same way, and offend only the sense of sight.

The members of the third class multiply very rapidly, and secrete a jelly, which, together with the plant, readily undergoes decomposition. These plants usually decay in the basins, and are represented in the water drawn from the taps only by a few fragments.

Of animals, two classes may be mentioned: the fixed or sessile forms, and the free swimming. Of the latter the *entomostraca* are the only troublesome forms, and these

mainly in the hot weather, when the rate of reproduction is very high. Of the sessile animals two are noteworthy, the fresh water sponge and the polyzoa. The latter usually encrust the gates and open ends of pipes. One gelatinous form lives in the ponds, — sometimes free, sometimes attached.

The comparatively small number of the polyzoa and their hardiness render them generally less important than some of the other organisms. The sponges are undoubtedly the most troublesome of the animals found in water supplies. They seem to have established themselves in the service-pipes of the Boston and Charlestown systems, but are not found in the Cambridge system. They readily decompose and strongly taint the water. They are now conspicuously absent in the sources of Boston's water supply.

Some of the lines upon which relief from the nuisance occasioned by these organisms may be sought are the following: Fixed plants can be cleared from ponds by the usual methods of raking. Improvements of the ponds by deepening and removing the loam will probably do much to check the growth of plants in groups two and three.

In Mr. Parker's preliminary report, which is printed in the Appendix,* will be found some observations upon the changes undergone by water from one locality, under the different conditions of storage in a filter gallery, in an open and in a covered reservoir. These observations have a great practical value, and demonstrate the value of covered reservoirs as a protection against the vegetable life, which seems to be the ordinary source of the disagreeable tastes and smells so common in our ponds and reservoirs.

Four rivers in the State have been systematically examined. These are the Taunton, the Blackstone, the Charles, and the Merrimack.

In the study of composition of river waters and the changes which they undergo in their progress, we must, in addition to the chemical determinations, bring into our consideration the geology and surface topography of the region through which the rivers flow. Wooded and swampy lands will give to their waters, with sluggish flow, high color

* See Appendix A.

and much soluble vegetable matters. Barren and rocky districts have rapid streams with little organic impurity and more or less mineral matter, according to the character of the rocks over which they flow.

Deep mountain lakes furnish water of high purity, without odor or color, and the waters of shallow lakes and ponds in low rolling country are generally colored from dissolved vegetable matters, and often have a distinct odor from aquatic growths of vegetable or animal origin.

Any investigation, therefore, into the pollution of streams by the drainage of human habitations or by manufacturing refuse, presupposes the study of the streams themselves, and the nature of their mineral and organic contents before they reach the point of pollution from sewage or similar drainage.

It is well to bear in mind that, although the admission of sewage into streams constitutes the principal and dangerous pollution, natural waters, far removed from human settlement, may be impure and repellent by reason of the products of vegetable and animal growth and decay. Because a stream is dark colored or is distasteful, and contains organic matter and products of putrefactive change, we must not take it for granted that it is contaminated by human refuse, or that it is dangerous in containing, necessarily, the germs of specific disease.

One chemical analysis of the water from a stream will not tell us (except in extreme cases) whether the stream is or is not contaminated dangerously with sewage. Indeed, many analyses of the water taken at random at different seasons may often fail to give us this information. We need to know what is the character of the water under normal conditions of rainfall, and also what it is in dry seasons, and when the water is unusually high. When a stream is swollen after heavy rains the water is turbid from suspended earthy matters and matters of organic origin washed down from the banks of the stream. An analysis made under these conditions will give a very different result from what would be obtained during summer heat and drought. Yet the knowledge of the character of the water under both con-

ditions is a matter of importance, in the study of the changes which a stream undergoes as it flows through a populous and manufacturing district.

Further, the degree of the pollution of a stream will obviously depend on the relation between the volume of the water flowing and the amount of contaminating material which enters it. The fouling of small streams by an amount of drainage which a large river would absorb without noticeable effect, is a matter of common observation. Nevertheless, when it concerns the matter of a supply of water for drinking purposes it is of the first importance to keep a jealous watch over the effect of an increasing volume of drainage entering rivers even of large size.

In the chemical analyses of the waters of the rivers (as well as the water supplies of the State in general) those substances have been determined which experience has shown to be the most important in influencing the character of water when used for domestic purposes. Briefly expressed, the scheme of analysis is as follows: The water is inspected for turbidity and sediment. The odor at ordinary temperatures, and at a point near boiling, is noted. Its color is recorded on a scale formed by adding the so-called Nessler reagent to varying amounts of ammonium chloride. This scale is the same as that used in the determination of free and albuminoid ammonia. Color 1 is a distinct yellowish brown when seen in a depth of five or six inches; 2 is a decided yellowish brown. On this scale Cochituate water as drawn from a faucet is on an average about 0.35. The "total solids" express the amount of both organic and mineral matters which the water contains. The "loss on ignition" represents in most of the surface waters very closely the organic matters, and the "fixed solids" those of mineral origin. And here it should be said that it has been the usual practice in carrying out these analyses to include the sediment and suspended matters in the determinations, except in those cases where the amount of undissolved matters is excessive by reason of heavy rains or other causes. In such cases the determination has been made on both the unfiltered and filtered sample.

"Free ammonia" is one of the products of the decay of

organic nitrogenous matter, either vegetable or animal, and "albuminoid ammonia" represents the amount of nitrogenous matter which is capable of giving ammonia in the process of decay. The "nitrogen in the form of nitrates" expresses the completion of changes which go on in nitrogenous matters in their progress from the organized to the inorganic condition.

Chlorine is generally present in water as chloride of sodium or common salt (one part of chlorine being equivalent to 1.65 parts of common salt). It may come from the soils and rocks over and through which the water passes, and from proximity to the sea, and it may also come from the waste products of human life and manufacture. It is this latter origin that gives it its great significance in water analyses as a possible indication of sewage, in which it is always present in considerable amount.

In the following table of analyses of four of the rivers of the State these determinations have been arranged in two groups, in order to bring together the determinations which are most closely related to one another. Thus, we have a table of *Organic Contents*, in which will be found the nitrogen in the form of free ammonia, in the form of albuminoid ammonia, and in the form of nitrates. With these is given the color of the water (on the scale mentioned above), since a very close correspondence has been made out between the depth of the color (which represents the vegetable organic matter in solution) and the amount of albuminoid ammonia.

In the other table of *Mineral Contents* the fixed solids express the amount of the mineral matters present, and the chlorine the contents of salt. The loss on ignition, as before said, is approximately the total amount of organic matter present, irrespective of its origin and character. The turbidity is given in this table, since it bears a close relation to the amount of solids determined by analysis. The chemical results embrace a period of seven months, from June to December.

The study of these tables is interesting and profitable, but as they cover only a part of the year any conclusions drawn from their study in their present form may have to be modified as the work progresses. Moreover, the past summer

was one of unusual rainfall, and the waters of this period cannot be considered as normal.

The collection of the samples of water was so planned that the waters of any one river should be taken from the various stations as near as possible on the same day. Even with this precaution to ensure comparable results local rains have at times a disturbing influence. The samples taken from the tributaries of the rivers are given in the same series as the rivers, but they were not as a rule collected at the same time.

The Taunton River.

The Taunton River represents a drainage area of 450 square miles. Within this area the waters of the river and its tributaries have been examined at nine stations, mainly in the eastern portion; but the monthly samples from these points were not always collected on the same day. The analyses have been arranged in three groups. First, the Salisbury Brook above Brockton, which furnishes the water supply of the city, Salisbury Plain River below Brockton, and the Taunton River at Sturtevant's Bridge, Bridgewater, just above its junction with the Nemasket. In the second group are the waters brought in by the Nemasket, namely: Elders Pond, Little Quittacas Pond, Assowompset Pond, the Nemasket at Middleborough, and also at the Old Mill just before it joins the Taunton. In the third group are two stations on the Taunton River, one just below its junction with the Nemasket at Dunbar's Bridge, and the other at the city of Taunton (see Tables Ia and Ib). It would be interesting in studying the character of the waters of this area to know the kind of water brought in by the eastern tributaries, and those draining North Easton and Bridgewater, which flow into the Taunton before its junction with the Nemasket. On comparing the character of the first two groups one is first impressed with the fact that the waters from the north are high colored, and that those from the south, brought in by the Nemasket, have but little color. This high color is accompanied, as usual, with high albuminoid ammonia. The lighter colored waters from the south, with lower amount of albuminoid ammonia, have a

TABLE I. "A."

TAUNTON RIVER AND TRIBUTARIES.

(ORGANIC CONTENTS). Parts in 100,000.

NORTHERN TRIBUTARIES.

1887.	Salisbury Brook, Brockton Storage Reservoir. Color.	Free Ammonia	Albuminoid Ammonia.	Nitrogen as Nitrates.		Salisbury Plain River, Brockton. Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.		Taunton River, Above the Nemasket, Bridgewater. Color.	Free Ammonia	Albuminoid Ammonia.	Nitrogen as Nitrates
June, .	1.2	.0010	.0394	.006	Receives drainage of Brockton between the points at which the samples were taken, as indicated in the analyses at the right and left of this space.	–	–	–		Receives many tributaries between these points.	–	–	–	–
July, .	1.2	.0016	.0370	.004		–	–	–	–		1.3	.0036	.0351	.007
August,* .	1.0	.0017	.0858	.003		–	–	–	–		–	–	–	–
September,	0.9	.0009	.0978	.003		–	–	–	–		1.0	.0007	.0342	.007
October, .	0.8	.0068	.0518	.008		1.3	.0320	.0150	.070		1.5	.0014	.0306	.013
November, .	1.0	.0062	.0345	.014		–	–	–	–		1.4	.0021	.0358	.008
December, .	0.8	.0046	.0327	.010		–	–	–	–		1.5	.0034	.0336	.012
Mean, . .	1.0	.0033	.0541	.007		–	–	–	–		1.5	.0022	.0338	.009

* This sample was taken early in September.

SOUTHERN TRIBUTARIES.

1887.	Elder's Pond, Lakeville. Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.	Little Quittacas Pond, Lakeville. Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.	Assowompset Pond, Lakeville. Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.	Nemasket River, Middleborough. Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.	Nemasket River, at Old Mill, Bridgewater. Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates
June, . .	–	–	–	–	–	–	–	–	–	–	–	–	0.6	.0005	.0200	.000	–	–	–	–
July, . .	–	–	–	–	–	–	–	–	–	–	–	–	0.7	.0005	.0214	.000	0.5	.0005	.0193	.000
August, .	–	–	–	–	–	–	–	–	–	–	–	–	0.35	.0002	.0170	.000	–	–	–	–
September,	0.0	.0003	.0130	.003	0.15	.0007	.0170	.007	0.1	.0009	.0154	.003	0.2	.0001	.0184	.000	0.2	.0003	.0142	.013
October, .	–	–	–	–	–	–	–	–	–	–	–		0.5	.0004	.0205	.009	0.3	.0014	.0202	.003
November, .	–	–	–	–	–	–	–	–	–	–	–	–	0.1	.0000	.0130	.003	0.55	.0018	.0191	.002
December, .	–	–	–	–	–	–	–	–	–	–	–	–	0.5	.0000	.0210	.002	0.9	.0008	.0214	.008
Mean, . .	–	–	–	–	–	–	–	–	–	–	–	–	0.4	.0003	.0188	.002	0.5	.0006	.0188	.005

RIVER BELOW JUNCTION.

Taunton River — At Dunbar's Bridge, Bridgewater. Color.	Free Ammonia	Albuminoid Ammonia.	Nitrogen as Nitrates	At Taunton. Color.	Free Ammonia	Albuminoid Ammonia	Nitrogen as Nitrates	1887.
2.0	.0032	.0320	.000	1.2	.0034	.0322	.013	June.
–	–	–	–	1.1	.0030	.0265	.013	July.
1.7	.0023	.0340	.003	1.3	.0043	.0271	.007	August.
1.4	.0013	.0241	.007	1.5	.0047	.0302	.007	September.
1.0	.0008	.0216	.007	1.0	.0004	.0212	.008	October.
1.1	.0013	.0285	.010	1.4	.0026	.0286	.010	November.
–	–	–	–	1.5	.0024	.0334	.010	December.
1.4	.0018	.0280	.005	1.3	.0030	.0285	.009	Mean.

TABLE I. "B."

TAUNTON RIVER AND TRIBUTARIES.

NORTHERN TRIBUTARIES

(MINERAL CONTENTS.) PARTS IN 100,000.

1887	Salisbury Brook, Brockton Storage Reservoir: Turbidity	Total Solids	Loss on Ignition	Fixed Solids	Chlorine		Salisbury Plain River, Brockton: Turbidity	Total Solids	Loss on Ignition	Fixed Solids	Chlorine		Taunton River, above the Nemasket, Bridgewater: Turbidity	Total Solids	Loss on Ignition	Fixed Solids	Chlorine
June,	Decided,	4.42	1.57	2.85	[illegible]	Receives Drainage of Brockton.	-	-	-	-	-	Receives many tributaries between these points.	-	-			-
July,	Decided,	4.32	1.70	2.62	.29		-	-	-	-	-		Very slight,	[illegible]	2.15	4.40	.57
August,*	Heavy,	5.80	2.92	2.88	.33		-	-	-	-	-		-	-	-	-	-
September,	Heavy,	5.95	2.95	3.00	.30		-	-	-	-	-		Decided	7.00	2.10	4.90	.69
October,	Decided,	4.50	2.15	2.35	.37		Heavy,	10.60	2.90	7.70	1.20		Decided,	6.55	1.60	4.95	.72
November,	Slight,	4.45	2.15	2.30	.37		-	-	-	-	-		Decided,	7.50	3.45	4.05	.69
December,	Decided,	5.15	2.30	2.85	.38		-	-	-	-	-		Decided,	7.45	3.25	4.20	.70
Mean,	-	4.95	2.27	2.67	.33		-	-		-	-			7.01	2.51	4.50	.67

* This sample was taken early in September.

SOUTHERN TRIBUTARIES.

1887	Elder's Pond, Lakeville: Turbidity	Total Solids	Loss on Ignition	Fixed Solids	Chlorine	Little Quittacas Pond, Lakeville: Turbidity	Total Solids	Loss on Ignition	Fixed Solids	Chlorine	Assowompset Pond, Lakeville: Turbidity	Total Solids	Loss on Ignition	Fixed Solids	Chlorine	Nemasket River, Middleborough: Turbidity	Total Solids	Loss on Ignition	Fixed Solids	Chlorine	Nemasket River at Old Mill, Bridgewater: Turbidity	Total Solids	Loss on Ignition	Fixed Solids	Chlorine
June,	-	-	-	-		-	-	-	-	-	-	-	-	-	-	Slight,	3.47	2.05	1.42	.49		-	-	-	-
July,	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	None,	3.60	1.30	2.30	.30	None,	3.45	1.10	2.35	.43
August,	-	-	-		-	-	-	-	-	-	-	-	-		-	None,	3.10	1.30	1.80	.48	-	-	-	-	-
September,	Distinct,	2.50	0.57	1.93	.41	Slight,	2.97	0.87	2.10	.48	Distinct,	2.95	0.90	2.05	.48	Slight,	3.27	1.05	2.22	.47	Very slight,	3.70	0.85	2.85	.51
October,		-	-	-	-		-	-	-	-	-	-	-	-	-	Very slight,	3.75	1.10	2.65	.51	Very slight,	3.90	1.30	2.60	.53
November,	-	-	-	-	-	-	-		-	-	-	-	-	-	-	Very slight,	3.40	1.30	2.10	.47	Very slight,	4.20	1.30	2.90	.52
December,		-	-	-			-	-	-	-	-	-		-	-	Very slight,	4.45	1.70	2.75	.52	Very slight,	4.90	1.60	3.30	.59
Mean,	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	3.58	1.40	2.18	.48	-	4.03	1.23	2.80	.53

RIVER BELOW JUNCTION

TAUNTON RIVER —

Dunbar's Bridge, Bridgewater: Turbidity	Total Solids	Loss on Ignition	Fixed Solids	Chlorine	At [illegible]: Turbidity	Total Solids	Loss on Ignition	Fixed Solids	Chlorine	1887
Very slight,	6.57	3.27	3.30	.42	Slight,	4.97	1.85	3.12	.48	June.
-	-	-	-	-	Slight,	6.20	1.55	[illegible]	.48	July.
Very slight,	6.50	2.87	3.63	.51	Very slight,	5.60	1.82	3.78	.52	August.
Decided,	5.80	1.85	3.95	.60	Slight,	5.85	1.70	4.15	.59	September.
Slight,	5.25	1.15	4.10	.65	Slight,	6.10	1.70	4.40	.72	October.
Very slight,	6.30	2.45	3.85	.72	Slight,	6.65	3.00	3.65	.73	November.
-	-	-	-	-	Distinct,	6.50	3.00	3.50	.58	December.
-	6.28	2.51	3.77	.58	-	5.84	2.09	3.75	.59	Mean.

very slight effect in reducing the intensity of the color in the northern waters, on account of the much smaller volume of water flowing in the Nemasket.

The Taunton River, after receiving the purer waters of the Nemasket, is but slightly altered in color, and the free and albuminoid ammonia are not much reduced. The waters from the north are also more turbid, and carry more earthy and flocculent sediment than those from the south. To this suspended matter, as well as to the organic matter in solution, much of the albuminoid ammonia is due. Thus the sample for October from the Brockton storage-reservoir, on Salisbury Brook, which gave .0518 parts of albuminoid ammonia, gave only .0282 after simple filtration through paper. The high loss on ignition in this water, nearly one-half of the total solids, points also to a large amount of organic matter. The mineral matters, or fixed solids, increase in the northern tributaries from 2.67 at Salisbury Brook to 4.50 at Sturtevant's Bridge, and the chlorine, which generally increases in the same ratio as the fixed solids, rises from 0.33 to 0.67 parts. In the southern tributaries we have much less solid matter brought in, both organic and mineral. The turbidity and sediment are, as a rule, less, and the fixed solids and loss on ignition are both lower.

After the union of the rivers the Taunton, owing to its much greater volume, preserves its general character, but the Nemasket waters have, nevertheless, a noticeable effect in lowering the free and albuminoid ammonia and the fixed mineral contents. In the further progress of the river to the city of Taunton, it remains substantially constant in composition; but the effect of the drainage of a populous region is shown in a decided tendency to an increase of the free ammonia.

The Charles River.

The Charles River has been examined regularly at five points, — at South Natick, West Roxbury, Newton Upper Falls, Waltham, and Watertown. There are, also, one analysis of the river water at Milford, three of Rosemary Brook, which joins the river below Newton Upper Falls, and five of Stony Brook, which flows into the river above

Waltham. If we compare the averages of the two end points in this series (see Table IIa and IIb), namely, the river at South Natick and at Watertown, the contrast is striking. The free ammonia is increased ten-fold, the nitrogen as nitrates three-fold, the fixed solids rise from 3.83 to 5.54 parts, the chlorine from 0.43 to 0.69 parts, and there is a decrease in color in the proportion of 84 to 57. In so far as these figures express in a general way the tendency to progressive pollution they convey important information, but they are misleading if they give the idea that the river at Watertown always bears this relation to the river at South Natick. If we compare the analyses of the waters from these two stations in July, we find the composition nearly identical as regards organic contents; but in November, the free ammonia and nitrates are very much higher in the river at Watertown. A single random analysis may sometimes tell us a good deal about a water, but it may lead to serious error if we attempt to get from it more information than the actual figures tell us of the composition of the one sample, taken under certain conditions and at a certain time. The danger of error decreases with the number of analyses and the length of time covered by the investigation, but it is not entirely eliminated until we are thoroughly acquainted with causes of accidental changes in a stream, as well as with those which are regular and normal.

The high albuminoid ammonia of the water at South Natick is normal if we take into consideration the general average high color of this water, and the low free ammonia associated with it points to the vegetable nature of this impurity. At Watertown the water is generally of lower color with a tendency to high free ammonia, conditions which point to contamination by drainage.

The mineral contents of surface waters are not, as a rule, subject to such irregular and fitful changes as the organic contents. Thus, in the Charles River the chlorine increases steadily, almost without break, from Milford to Watertown. The changes show great regularity both in the waters of each station when compared with themselves, and also from station to station as the stream flows onward. In general,

TABLE II. "A."

CHARLES RIVER.

(ORGANIC CONTENTS). PARTS IN 100,000.

1887.	At Milford.				At South Natick.				At West Roxbury. Brookline Supply.			
	Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.	Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.	Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.
June, .	-	-	-	-	-	-	-	-	1.2	.0042	.0423	.000
July, .	-	-	-	-	0.9	.0010	.0256	.000	0.9	.0011	.0251	.000
August,	-	-	-	-	1.4	.0012	.0302	.007	1.1	.0002	.0274	.007
September, .	-	-	-	-	0.75	.0003	.0348	.003	0.8	.0010	.0322	.007
October,	-	-	-	-	0.5	.0005	.0225	.010	0.4	.0005	.0202	.013
November,	-	-	-	-	0.6	.0000	.0267	.008	0.6	.0008	.0218	.008
December, .	1.1	.0035	.0269	.008	0.9	.0020	.0276	.010	0.7	.0009	.0278	.018
Mean, .	-	-	-	-	0.84	.0008	.0284	.006	0.8	.0012	.0281	.008

1887.	At Newton Upper Falls.				Tributaries. Rosemary Brook, Wellesley.				Tributaries. Stony Brook, Waltham. Cambridge Supply.			
	Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.	Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.	Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.
June, .	1.0	.0020	.0396	.000	-	-	-	-	1.3	.0060	.0552	.000
July, .	0.7	.0004	.0202	.000	-	-	-	-	0.7	.0006	.0297	.003
August,	1.0	.0008	.0249	.000	-	-	-	-	1.0	.0024	.0266	.000
September, .	0.7	.0011	.0307	.007	-	-	-	-	0.7	.0061	.0366	.003
October,	0.4	.0000	.0208	.005	0.3	.0008	.0170	.019	0.7	.0074	.0340	.007
November,	0.0	.0004	.0242	.008	0.1	.0005	.0131	.030	0.45	.0071	.0262	.008
December, .	0.7	.0004	.0240	.018	0.3	.0018	.0193	.025	-	-	-	-
Mean, .	0.7	.0007	.0263	.005	0.23	.0010	.0166	.024	0.61	.0049	.0347	.004

1887.	At Waltham.				At Watertown.			
	Color	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.	Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.
June, .	1.2	.0044	.0440	.000	-	-	-	-
July, .	0.6	.0034	.0240	.000	0.9	.0006	.0307	.003
August,	0.7	.0052	.0270	.003	0.6	.0075	.0237	.035
September, .	0.55	.0027	.0271	.007	0.6	.0009	.0291	.013
October,	0.5	.0010	.0241	.007	0.45	.0056	.0249	.026
November,	0.5	.0010	.0192	.000	0.3	.0305	.0255	.040
December, .	[illegible]	.0026	.0272	.020	-	-	-	-
Mean, .	0.65	.0029	.0276	.007	0.57	.0086	.0265	.023

TABLE II. "B."

CHARLES RIVER.

(MINERAL CONTENTS). PARTS IN 100,000.

1887	At Milford.					At South Natick.					At West Roxbury. Brookline Supply.				
	Turbidity.	Total Solids.	Loss on Ignition.	Fixed Solids.	Chlorine.	Turbidity.	Total Solids.	Loss on Ignition.	Fixed Solids.	Chlorine.	Turbidity.	Total Solids.	Loss on Ignition.	Fixed Solids.	Chlorine.
June, .	-	-	-	-	-	-	-	-	-	-	Very slight,	5.15	2.27	2.88	.44
July, .	-	-	-	-	-	Very slight,	5.10	1.80	3.30	.35	Very slight,	4.92	1.77	3.15	.38
August,	-	-	-		-	None, .	5.05	1.97	3.08	[illegible]	Very slight,	5.85	1.90	3.95	.32
September,	-	-	-	-	-	Distinct, .	5.60	1.00	4.00	.44	Slight, .	5.67	1.49	4.18	.39
October,	-	-	-	-	-	Very slight,	4.90	1.10	3.80	.47	Very slight,	4.80	1.15	3.65	.53
November, .	-	-	-	-	-	Slight, .	5.30	1.55	3.75	.54	Slight, .	5.85	1.15	4.70	.50
December, .	Very slight,	4.50	2.10	2.40	.30	Slight, .	5.85	1.70	4.15	.45	Distinct, .	6.20	1.95	4.25	.52
Mean, .	-	-	-	-	-	-	5.45	1.62	3.83	.43	-	5.49	1.67	3.82	.45

1887	At Newton Upper Falls.					Rosemary Brook, Wellesley.					Stony Brook, Waltham. Cambridge Supply.				
	Turbidity.	Total Solids.	Loss on Ignition.	Fixed Solids.	Chlorine.	Turbidity.	Total Solids.	Loss on Ignition.	Fixed Solids.	Chlorine.	Turbidity.	Total Solids.	Loss on Ignition.	Fixed Solids.	Chlorine.
June, .	Very slight,	5.95	1.92	4.03	.39	-	-	-	-	-	Very slight,	6.72	3.25	3.47	.45
July, .	Slight, .	5.07	1.62	3.45	.38	-	-	-	-	-	Distinct, .	6.25	1.72	4.53	[illegible]
August,	Very slight,	5.60	1.80	3.80	.38	-	-	-	-	-	Very slight,	5.92	1.80	4.12	.45
September,	Slight, .	5.62	1.40	4.22	.43	-	-	-	-	-	Decided, .	6.30	1.12	5.18	.42
October,	Very slight,	5.30	1.25	4.05	.50	Distinct earthy,	5.40	0.80	4.60	.64	Distinct, .	6.05	1.25	4.80	.43
November, .	Slight, .	5.65	0.95	4.70	.62	Very slight,	[illegible]	0.95	4.40	.65	Slight, .	6.00	1.75	4.25	.48
December, .	Slight, .	6.20	1.80	4.40	.56	Slight,	5.85	1.25	4.60	.67	-	-	-	-	-
Mean, .	-	5.63	1.53	1.09	.48	-	5.53	1.00	4.53	.65	-	6.20	1.81	4.39	.45

1887	At Waltham.					At Watertown.				
	Turbidity.	Total Solids.	Loss on Ignition.	Fixed Solids.	Chlorine.	Turbidity.	Total Solids.	Loss on Ignition.	Fixed Solids.	Chlorine.
June, .	-	6.07	2.32	3.75	.40	-	-	-	-	-
July, .	Very slight,	5.50	1.80	3.70	.40	Distinct, .	6.75	2.00	4.75	.60
August,	Distinct, .	6.20	1.37	4.83	.35	Slight, .	6.97	1.30	[illegible]	.59
September,	Slight, .	6.27	1.40	4.87	.50	Distinct, .	6.90	1.15	5.75	.62
October,	Slight, .	5.90	1.10	4.80	.57	Distinct, .	7.15	1.40	5.75	.75
November, .	Decided,	6.20	1.75	4.45	.66	Distinct, .	7.80	2.00	5.80	.88
December, .	Distinct, .	6.85	2.10	4.75	[illegible]	-	-	-	-	-
Mean, .	-	6.14	1.69	4.45	.51	-	7.11	1.57	5.54	[illegible]

TABLE III. "A."

BLACKSTONE RIVER.

(ORGANIC CONTENTS). PARTS IN 100,000.

	Holden Storage Reservoir.				Leicester Storage Reservoir.					Worcester, 1 Mile below Outlet of Worcester Sewer.				Uxbridge, Diluted by Lake Quinsigamond and other Tributaries.				Millville.			
	Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.	Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.		Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.	Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.	Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.
1887.																					
June, . .	0.1	.0002	.0148	.013	0.10	.0001	.0131	.000	Receives many tributaries and the sewage of Worcester.	1.0	.0620	.3620	–	0.3	.1140	.0361	.019	0.2	.0565	.0232	.006
July, .	–	–	–	–	–	–	–	–		0.2	.3670	.1340	–	0.4	.1320	.1330	.052	0.6	.0396	.0230	.013
August, .	0.6	.0019	.0220	.003	0.40	.0036	.0189	.003		2.0	.2000	.1280	.010	0.45	.0264	.0270	.065	0.5	.0050	.0243	.033
September, .	0.2	.0000	.0188	.000	0.15	.0014	.0184	.003		0.1	.2640	.1200	.013	0.3	.0492	.0216	.039	0.15	.0128	.0212	.033
October, .	0.4	.0000	.0236	.003	0.35	.0092	.0224	.007		1.3	.0884	.0376	.016	0.5	.1672	.0256	.026	0.3	.0776	.0232	.026
November, .	0.3	.0012	.0218	.000	0.50	.0112	.0238	.006		*	.5300	.2630	.025	0.4	.1888	.0192	.015	0.2	.0896	.0172	.015
December, .	0.2	.0006	.0170	.002	0.35	.0088	.0195	.007		0.9	.2180	.0600	.025	0.7	.1200	.0380	.025	0.5	.0636	.0312	.018
Mean, . .	0.3	.0607	.0197	.004	0.31	.0057	.0194	.004		0.92	.2471	.1578	.018	0.44	.1148	.0430	.034	0.34	.0492	.0233	.021

* Colored by Iron.

TABLE III. "B."

BLACKSTONE RIVER.

(MINERAL CONTENTS). PARTS IN 100,000.

	Holden Storage Reservoir.					Leicester Storage Reservoir.					Worcester, 1 Mile below Outlet of Worcester Sewer.					Uxbridge, Diluted by Lake Quinsigamond and other Tributaries.					Millville.				
	Turbidity.	Total Solids.	Loss on Ignition.	Fixed Solids.	Chlorine.	Turbidity.	Total Solids	Loss on Ignition.	Fixed Solids.	Chlorine.	Turbidity.	Total Solids.	Loss on Ignition.	Fixed Solids.	Chlorine.	Turbidity.	Total Solids.	Loss on Ignition.	Fixed Solids	Chlorine.	Turbidity.	Total Solids.	Loss on Ignition.	Fixed Solids.	Chlorine.
1887.																									
June, .	Slight, .	2.27	1.07	1.20	.14	Slight, .	2.92	0.87	2.05	.14	Thick and dirty, .	22.90	9.30	13.60	1.47	Decided, .	0.65	1.52	5.13	.77	Slight, .	6.52	1.82	3.70	.53
July, . .	–	–	–	–	–	–	–	–	–	–	Thick and dirty, .	42.00	3.25	38.75	2.12	Distinct, .	7.27	1.27	6.00	.82	Distinct, .	4.80	1.00	3.80	.42
August, .	Distinct, .	3.07	1.62	1.45	.08	Very slight,	3.20	1.30	1.00	.11	Thick and dirty, .	18.50	3.70	14.80	1.24	Distinct, .	7.05	1.65	5.40	.66	Slight, .	5.22	1.07	4.15	.41
September, .	Decided, .	2.50	0.90	1.60	.15	Decided, .	2.90	0.55	2.35	.14	Thick and dirty, .	23.90	7.30	16.60	.93	Distinct, .	7.37	1.40	5.97	.71	Slight, .	5.30	1.35	3.95	.52
October, .	Decided, .	2.65	0.75	1.90	.13	Slight, .	3.25	0.75	2.50	.15	Thick and dirty, .	16.60	6.10	10.50	.90	Distinct, .	7.55	1.35	6.20	.81	Distinct, .	5.50	1.35	4.15	.59
November, .	Decided, .	2.60	0.95	1.65	.15	Distinct, .	3.30	1.20	2.10	.16	Thick and dirty, .	Filt. 34.00	10.20	23.80	1.46	Distinct, .	7.45	1.20	6.25	.96	Distinct, .	5.20	1.10	4.10	.59
December, .	Distinct, .	2.65	0.75	1.90	.15	Slight, .	3.35	1.00	2.35	.17	Thick and dirty, .	16.60	6.30	10.30	1.63	Decided, .	8.15	1.65	6.50	.80	Distinct, .	6.60	1.25	4.35	.53
Mean, . .	–	2.62	1.01	1.62	.13	–	3.15	0.95	2.21	.15	–	24.93	6.59	18.34	1.39	–	7.36	1.43	5.92	.79	–	5.31	1.28	4.03	.51

the months lowest in chlorine throughout the series were July and August, and the highest November and December. If we had only the chlorine determination at South Natick in November and the chlorine at Watertown in August, the contamination of the stream as shown by these figures from South Natick to Watertown would be as 54 to 59 (1 to 1.1), whereas the relation between the two determinations in August shows 39 to 59 (1 to 1.69), and between the two in November as 54 to 80 (1 to 1.63). The evidence of pollution by drainage which we get by the determination of the free and albuminoid ammonia must, in this way, always be confirmed by the evidence furnished by the contents of chlorine; but to be sure of our ground we must know that the conditions under which the samples were taken make the determinations fairly comparable.

The nitrogen in the form of nitrates at Watertown is higher than in the upper waters of the Charles. This shows a complete oxidation of a small portion of the nitrogenous matter, presumably of animal origin, and it affords an additional proof of previous contamination. The process of nitrification is not very active in river waters, and the nitrates do not there assume the same significance as they do in ground waters.

The Blackstone River.

The Blackstone River affords a good instance of intense pollution of a stream by excessive sewage and the waste products of factories, and its partial purification by subsequent dilution. (See Tables IIIa and IIIb.) The head waters of the river, represented by the Holden and Leicester storage reservoirs, are fairly good waters of moderate color, with a marked tendency, in the Leicester reservoir, towards the development of free ammonia, which, however, is not accompanied by high chlorine.

The river about one mile below Worcester, after having received the sewage of the city and the waste liquors from the Washburn & Moen Wire Works, is excessively foul. It is muddy and dirty in appearance, and full of dark flocculent, suspended matter. It has frequently an acid reaction

from the pickling liquors. The water at this point may be fairly called sewage.

At Uxbridge the river has received the water from Lake Quinsigamond and other tributaries, and shows in consequence some improvement, but not enough to enable it to be called anything else than foul.

At Millville, the lowest point at which samples have been taken, the water has lost some of its objectionable features, but it is still unfit for use for drinking. The mineral matters and chlorine at this point are not excessive, but the high free ammonia shows the continued presence of putrefying material.

The Merrimack River.

The Merrimack River is being studied (as shown in Tables IVa and b) at six points, from Nashua, N. H., to Haverhill, Mass., as well as at its head waters at Lake Winnepiseogee, and on four of its tributaries. If we compare the waters of the Lake with that of the Merrimack at Haverhill there is a striking difference in composition. The former is colorless and of high purity, and the latter is colored, and carries a good deal of organic and mineral matter in suspension and solution. Again, if we compare the two extremes on the river itself at Nashua and Haverhill we still notice a wide difference in character. At Haverhill the free ammonia is double that at Nashua, the albuminoid ammonia one and a half times as much, and there is a slight increase in the nitrates. The fixed solids are increased fourteen per cent., the volatile solids eleven per cent., and the chlorine twelve per cent.

The changes between the stations immediately succeeding each other are less marked, but they are, in general, in the line of progressive contamination. As has been previously noted, the evidence derived from the solid contents and the chlorine is more uniform in this regard than that derived from the nitrogenous matter. In the latter we notice considerable fluctuation, but in the former the increase is quite uniform

The Merrimack is a good instance of the ability of a large river to receive a good deal of polluting material, in the

TABLE IV. B

MERRIMACK RIVER.

(MINERAL CONTENTS). PARTS IN 100,000.

1887.	Winnipiseogee River, at Lake Village.					At Nashua.					Above Lowell.				
	Turbidity.	Total Solids.	Loss on Ignition.	Fixed Solids.	Chlorine	Turbidity.	Total Solids.	Loss on Ignition.	Fixed Solids	Chlorine.	Turbidity.	Total Solids.	Loss on Ignition.	Fixed Solids.	Chlorine.
June, . .	Slight, .	2.35	1.00	1.35	.14	Slight, .	4.37	1.05	2.42	.21	Slight, .	3.90	1.55	2.35	.16
July, . .	None, .	2.10	0.80	1.30	.14	Slight, .	4.50	1.30	3.20	.12	Very slight,	3.55	1.15	2.40	.12
August,	Very slight,	2.22	0.52	1.70	.18	Very slight,	3.92	1.07	2.85	.12	Very slight,	4.07	1.15	2.92	.14
September, .	Slight, .	2.22	0.60	1.62	.14	Distinct, .	3.75	0.85	2.90	.18	Slight, .	3.95	0.80	3.15	.20
October,	Very Slight,	2.10	0.45	1.65	.10	Distinct, .	3.85	0.70	3.15	.18	Very slight,	3.85	0.70	3.15	.19
November, .	Very Slight,	2.05	0.65	1.40	.11	Decided, .	4.25	1.20	3.05	.20	Decided, .	†5.15	1.25	3.90	.24
December. .	Very Slight,	1.80	0.30	1.50	.14	Very decided,	*3.30	1.25	2.05	.12	Decided, .	5.60	1.50	4.10	.15
Mean, .	-	2.12	0.62	1.50	.13	-	3.99	1.19	2.80	.18	-	4.29	1.15	3.14	.17

1887.	Opposite Lowell, above the Concord.					Above Lawrence.				
	Turbidity.	Total Solids.	Loss on Ignition.	Fixed Solids.	Chlorine	Turbidity.	Total Solids.	Loss on Ignition.	Fixed Solids.	Chlorine
June, . .	Slight, .	4.40	1.82	2.58	.20	Distinct, .	4.41	1.76	2.65	.17
July, . .	Slight, .	4.25	1.25	3.00	.16	Distinct, .	4.60	1.00	3.60	.17
August,	Distinct, .	4.75	1.35	3.40	.16	Decided, .	6.40	1.40	5.00	.21
September, .	Decided, .	4.45	1.05	3.40	.22	Slight, .	4.70	0.95	3.75	.25
October,	Very slight,	4.10	0.65	3.45	.22	Slight, .	4.80	0.55	3.95	.28
November, .	Decided, .	5.85	1.50	4.35	.26	Decided, .	4.75	1.23	3.52	.24
December. .	Decided, .	5.60	1.30	4.30	.19	-	-	-	-	-
Mean, .	-	4.77	1.27	3.50	.20	-	4.94	1.20	3.74	.22

1887.	Below Lawrence.					Above Haverhill.				
	Turbidity.	Total Solids.	Loss on Ignition.	Fixed Solids.	Chlorine.	Turbidity	Total Solids.	Loss on Ignition.	Fixed Solids.	Chlorine.
June, . .	Distinct,	5.85	2.17	3.68	-	Decided, .	5.02	1.70	3.32	.15
July, . .	Distinct, .	5.05	1.57	3.48	.17	Distinct, .	4.42	1.22	3.20	.13
August,	Decided, .	6.37	1.15	5.22	.20	Decided, .	6.70	1.05	5.65	.20
September, .	Decided, .	4.90	1.15	3.75	.25	Very Slight,	4.65	0.95	3.70	.22
October,	Distinct, .	5.90	1.15	4.75	.29	Decided, .	5.35	1.45	3.90	.30
November, .	Distinct, .	5.10	1.35	3.75	.24	Distinct. .	5.30	1.55	3.75	.26
December. .	Decided, .	5.65	1.50	4.15	.20	Decided, .	5.75	1.55	4.20	.22
Mean, .	-	5.55	1.43	4.11	.22	-	5.31	1.35	3.96	.21

* This sample was filtered. The unfiltered sample from Nashua contained 8.90, 1.70, 7.20.

† Taken two days later than the others in November.

TRIBUTARIES.

1887.	Nashua River, at Clinton.					Nashua River, at Nashua					Assabet River, at Northborough.				
	Turbidity.	Total Solids	Loss on Ignition.	Fixed Solids.	Chlorine.	Turbidity,	Total Solids.	Loss on Ignition.	Fixed Solids.	Chlorine.	Turbidity.	Total Solids.	Loss on Ignition.	Fixed Solids.	Chlorine.
June, . .	Very slight,	4.22	1.17	3.05	.25	Slight, .	4.87	2.00	2.87	.43	Slight, .	5.37	2.42	2.95	.27
July, . .	Slight, .	4.47	1.52	2.95	.15	Slight, .	5.00	1.35	3.65	.38	Very slight,	5.32	1.42	3.90	.23
August, .	Slight, .	4.15	1.42	2.73	.12	Very slight,	4.92	1.00	3.92	.29	Slight, .	5.35	1.67	3.08	.29
September, .	Very slight,	3.90	1.05	2.85	.19	Distinct, .	4.90	0.85	4.05	.29	Distinct, .	4.85	1.20	3.65	.30
October, .	Slight, .	4.30	1.00	3.30	.27	Slight, .	5.45	1.30	4.15	.35	Distinct, .	5.40	1.30	4.10	.32
November, .	Slight, .	4.05	1.40	2.65	.25	Decided, .	5.55	1.30	4.25	.41	Decided, .	5.25	1.05	4.20	.31
December, .	Distinct, .	3.85	1.10	2.75	.22	Distinct, .	4.35	1.29	3.72	.28	Slight, .	4.70	1.45	3.25	.27
Mean, . .	-	4.13	1.24	2.89	.21	-	5.01	1.29	3.72	.35	-	5.18	1.50	3.68	.28

1887.	Concord River, at Lowell.					Shawsheen River, at Wilmington.				
	Turbidity.	Total Solids.	Loss on Ignition.	Fixed Solids.	Chlorine.	Turbidity.	Total Solids.	Loss on Ignition.	Fixed Solids.	Chlorine.
June, . .	-	-	-	-	-	None, .	4.92	1.22	3.70	.34
July, . .	-	-	-	-	-	Very slight,	6.95	2.10	4.85	.33
August, .	-	-	-	-	-	None, .	7.30	2.75	4.55	.36
September, .	-	-	-	-	-	None, .	4.00	1.00	3.00	.38
October, .	-	-	-	-	-	Very slight,	6.90	2.00	4.00	.48
November, .	-	7.05	2.35	4.70	.56	Slight, .	7.00	2.55	4.45	.47
December, .	-	-	-	-	-	Very slight,	6.50	1.80	4.70	.35
Mean, . .	-	-	-	-	-	-	6.09	1.92	4.18	.39

TABLE IV. "A."

MERRIMACK RIVER.

(ORGANIC CONTENTS). PARTS IN 100,000.

	Winnipiseogee River, at Lake Village.				At Nashua.*				Above Lowell.				Opposite Lowell, above the Concord.			
	Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.	Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.	Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.	Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.
1887.																
June,	0.0	.0002	.0076	.000	0.5	.0006	.0128	.007	0.4	.0020	.0122	.013	0.3	.0016	.0147	.013
July,	0.0	.0002	.0085	.000	0.4	.0002	.0143	.004	0.4	.0010	.0133	.003	0.4	.0002	.0170	.003
August,	0.0	.0005	.0077	.000	0.6	.0031	.0158	.007	0.0	.0027	.0177	.007	0.6	.0007	.0212	.007
September,	0.0	.0000	.0088	.007	0.15	.0011	.0169	.003	0.15	.0018	.0148	.007	0.2	.0022	.0182	.007
October,	0.0	.0000	.0098	.000	0.3	.0022	.0180	.007	0.4	.0042	.0152	.008	0.3	.0031	.0172	.010
November,	0.0	.0000	.0080	.003	0.35	.0018	.0196	.005	0.75‡	.0026	.0203	.009	0.75	.0012	.0209	.009
December,	0.0	.0000	.0107	.002	0.45	.0012	.0188	.010	0.4	.0007	.0169	.012	0.45	.0006	.0180	.011
Mean,	0.0	.0001	.0087	.002	0.39	.0015	.0166	.006	0.44	.0021	.0158	.008	0.43	.0014	.0182	.009

	Above Lawrence †				Below Lawrence.				Above Haverhill.			
	Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.	Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.	Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.
1887.												
June,	0.4	.0006	.0189	.009	0.5	.0003	.0182	.000	0.45	.0018	.0181	.006
July,	0.4	.0026	.0174	.007	0.5	.0004	.0194	.007	0.4	.0008	.0169	.007
August,	0.55	.0046	.0266	.013	0.55	.0033	.0288	.013	0.5	.0037	.0281	.010
September,	0.3	.0015	.0193	.016	0.25	.0002	.0214	.007	0.35	.0073	.0213	.003
October,	0.5	.0036	.0198	.009	0.5	.0000	.0242	.005	0.4	.0028	.0235	.017
November,	0.65	.0018	.0225	.010	0.45	.0022	.0250	.010	0.5	.0024	.0240	.007
December,	-	-	-	-	0.45	.0014	.0183	.013	0.45	.0044	.0228	.012
Mean,	0.47	.0024	.0207	.011	0.46	.0011	.0222	.009	0.43	.0033	.0221	.009

* The station at Nashua is above the mouth of the Nashua River.

† The results given for the river "above Lawrence" are the mean of two analyses of the water at 1 foot and at 6 feet below the surface, opposite the Lawrence Pumping Station, 50 feet from the northeast shore.

‡ This sample taken two days later than the others in November.

TRIBUTARIES.

	Nashua River, at Clinton.				Nashua River, at Nashua.				Assabet River, at Northborough.			
	Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.	Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.	Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.
1887.												
June,	0.3	.0018	.0175	.006	0.4	.0066	.0185	.007	0.0	.0032	.0240	.013
July,	1.2	.0032	.0340	.013	0.5	.0022	.0245	.007	0.6	.0060	.0240	.013
August,	0.9	.0020	.0239	.005	0.7	.0039	.0193	.010	0.8	.0061	.0303	.003
September,	0.4	.0012	.0166	.008	0.2	.0026	.0191	.007	0.5	.0037	.0238	.003
October,	0.4	.0008	.0216	.008	0.6	.0054	.0196	.009	0.65	.0030	.0324	.010
November,	0.55	.0008	.0196	.006	0.4	.0030	.0214	.009	0.3	.0018	.0212	.009
December,	0.3	.0008	.0180	.008	0.45	.0027	.0195	.010	0.8	.0058	.0238	.008
Mean,	0.58	.0015	.0216	.008	0.46	.0039	.0203	.008	0.05	.0043	.0256	.008

	Concord River, at Lowell.				Shawsheen River, at Wilmington.			
	Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.	Color.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.
1887.								
June,	-	-	-	-	0.9	.0013	.0232	.006
July,	-	-	-	-	1.5	.0010	.0440	.000
August,	-	-	-	-	1.6	.0016	.0431	.003
September,	-	-	-	-	0.2	.0005	.0110	.003
October,	-	-	-	-	1.3	.0010	.0260	.003
November,	0.8	.0074	.0375	.010	1.4	.0006	.0304	.007
December,	-	-	-	-	1.1	.0005	.0231	.020
Mean,	-	-	-	-	1.1	.0011	.0290	.006

form of sewage and manufacturing refuse from large cities, without becoming seriously polluted. It has in this respect not only the advantage of large volume, but it is unusually well aerated by agitation in rapids, dams and water-wheels, which, without doubt, have some influence in counteracting the influence of the organic matter. How far the results of chemical analysis would have been different in a summer of normal rainfall it is impossible to say. By referring to the tables it will be seen that the water samples examined were very generally turbid, owing to the frequent and heavy rains.

The tributaries of the Merrimack which have been examined, namely, the Nashua, Assabet, Concord and Shawsheen, are all less pure than the Merrimack at the points of junction, and contribute therefore to the impurities of the Merrimack. The Shawsheen is characterized by its high color, and its corresponding high albuminoid ammonia. It is, however, generally clear and free from sediment.

III.

Purification of Sewage by Applying it to Land.

In England, France and Germany, and to a limited extent in this country, sewage has been satisfactorily purified by applying it to land used for growing crops, with the result that the water flowing from underdrains was nearly as good as the supplies of drinking water of those countries, so far as chemical and biological examinations could determine.

The quantity which can be applied depends upon the permeability of the soil and the underlying strata, the amount of rainfall and the character of the crops.

In England from 2,000 gallons per acre per day to 6,000 gallons have been applied, giving an average of a little more than 4,000 gallons per acre per day where the rainfall is twenty-two inches in the year.

In Germany about 3,000 gallons per day are recorded, and near Paris, in a very open sand, about 11,000 gallons per acre have been applied in raising cabbages, but this amount would drown the crops on any land that could be cultivated without irrigation.

It is probable that upon ordinary farm land in Massachusetts 2,500 gallons per day per acre are as much as could be applied to any valuable grass crop, and there would be required 400 acres of irrigation ground for each million gallons of sewage. Or the city of Lawrence, using sixty gallons of water per inhabitant, would require an irrigation field of 1,000 acres, or one quarter of the area of the city to use in irrigation the dry-weather sewage of the city.

We may then conclude that desirable as the use of sewage in irrigation is, we cannot depend upon irrigation alone in the more thickly settled parts of the State for preventing the pollution of streams.

The limit to the quantity that can be applied in irrigation is injury to the crop. Some kinds of land are found to be capable of purifying a much larger quantity of sewage than the crop can bear, if the sewage be applied at intervals of time, leaving the land to drain and become more or less filled with air between the applications. This method is known as *intermittent filtration*. By this method the suspended matter is retained near the surface, and is to a great degree burned up, and the liquid percolating in thin and broken laminæ comes in contact with the air, and much that is held in solution is given up or changed, and the effluent proves to be effectually purified.

This purification was at first supposed to be due to the oxidizing effect of the air, but the experiments of Schloesing of France, and Frankland and Warington of England, prove that with this there must be the active presence of organisms to produce nitrification.

Schloesing found by passing sewage through glass tubes filled with baked sand and with marbles, —

First. No purification was produced.

Second. After a while the effluent was quite clear and free from organic matter.

Third. Upon applying chloroform to the tube, purification stopped and did not commence again till all traces of the chloroform were washed out.

He was thus confirmed in the conclusion that purification requires the active co-operation of organic life.

No purifying or nitrifying effect being produced at first by sand, in which organic life had been destroyed by heat,

and the nitrifying effect beginning after sewage had been some time passing through, he concluded that the sewage introduced the nitrifying elements, and that as their purifying action ceased when treated with chloroform and began again after the chloroform was washed out, he concluded these elements were living organisms.

Robert Warington in England has made many valuable experiments upon nitrification in soils and waters, and being confirmed in the view that it is due to living organisms has sought to determine the distribution of the nitrifying organism in the soil, and concludes that it is practically confined to the surface soil and occurs to a very small extent in a clay subsoil removed two or three feet from the surface.

Dr. Frankland of England, by experiments, passing sewage through two-inch glass tubes sixteen feet long, filled with sand or sand and chalk, found that about six gallons of London sewage can be satisfactorily purified per cubic yard in twenty-four hours. He concluded that purification is a process of oxidation, the products being carbonic and nitric acids, consequently a continual aeration of the soil is necessary.

With glass cylinders $10\frac{1}{2}$ inches in diameter filled with about five feet in depth of soil, he found, by applying sewage intermittently and at different rates to different soils, the following results : —

Darsley soil; a light brown loam, purified, 9.9 gallons per cubic yard in twenty-four hours.

Bennington soil; a porous gravel, which had been used five years for sewage irrigation, gave 7.6 gallons per cubic yard in twenty-four hours, of effluent "almost as good as London water."

Hambrook soil; a light reddish sand, did not at first purify but after a fortnight it began, but would not purify more than 4.2 gallons per cubic yard in twenty-four hours.

Barking soil; at first absorbed some fertilizing ingredients; but with 3.8 gallons in twenty-four hours showed increasing quantities of organic matter in the effluent for twelve weeks, and the effluent gradually became crude sewage.

The results with sand from Hambrook are like those obtained by Schloesing with sand and marbles. It took some

time, in this case two weeks, before the effluent began to show nitrification; whereas when loam from Darsley was used, or soil from Bennington which had previously been treated with sewage, nitrification began immediately.

The conclusion reached was that in the loam, nitrifying organisms existed as shown by Warington, and nitrification set in at once, while they did not exist in the sand and gravel but were introduced by the sewage and were retained in passing over the particles of sand, where they multiplied till they were in sufficient number to effect the nitrification of the sewage.

At the Clichy Laboratory, near Paris, experiments were made in a plate-glass tank, six and a half feet high and about eight inches square. One inch in depth of Paris sewage was put upon this sand daily for five years, with the result that the sand was generally clean, after the five years' use.

The quality of the effluent was excellent as shown by the following analysis in parts in 100,000: —

	Sewage strained through Paper.	Effluent.
Ammoniacal nitrogen,	2.69	.02
Albuminoid nitrogen,	0.406	.01
Nitric nitrogen,	0.04	1.96
	3.14	1.99

Frankland's experiments with sand, and with sand and chalk, gave the following results when discharging 5.6 gallons per day per cubic yard, or 45,000 gallons per acre if five feet deep: —

	Sewage.	Effluent — Through Sand.	Effluent — Through Sand and Chalk.
Solids in solution,	64.5	77.6	94.6
Organic carbon,	4.386	.734	.582
Organic nitrogen,	2.484	.108	.092
Ammonia,	5.557	.012	.016
Nitrogen as nitrates and nitrites,	.000	3.925	3.478
Total combined nitrogen,	7.060	4.043	3.583

The effluent through Bennington soil, five feet deep at the rate of 61,000 gallons per acre per day, Dr. Frankland said was "almost as good as London water."

The quantities of sewage applied in intermittent filtration, in which we have satisfactory analyses of the effluent, are those of experiments on material in glass tubes having areas from three square inches to eighty-seven square inches, and the amount of sewage applied and satisfactorily purified varied from 30,000 gallons per acre per day to 80,000 gallons per acre, upon a bed five feet deep. One soil tested failed to purify the lesser amount.

The amounts reported as applied to various filter beds in England and on the Continent are from 36,000 to 90,000 gallons per acre per day, but the analyses of the effluent when given are not so satisfactory as those obtained in the laboratories. From these results it appears that filter beds, if of proper material, can purify ten or twelve times as much sewage per acre as can be applied to our farm lands in irrigation.

It is upon the basis of these results that we must enter upon experiments to determine the amount of sewage we can in this climate purify with such material as is deposited in our valleys.

At present no one can tell in regard to any area that may be selected the character of the effluent that will result from the application of sewage in large or small quantity, nor the effect of our winters nor of long storms upon the efficiency of the bed, nor the proper intervals for application.

This knowledge can be obtained only by trial and careful observation. To make such trials in the most economical way to obtain reliable information and actual additions to the knowledge of the world upon this subject for immediate and urgent use in this State, the Board of Health has established an experimental station and is now actively pursuing the investigation in regard, first to the soils, sands and gravels to be found in its neighborhood, afterward to be replaced by those which may be proposed for such use in other localities.

Sewage Experimental Station at Lawrence.

Wherever sewage is to be purified in any manner it is important on the ground of economy that it be collected and conveyed to the purifying grounds separate from and undiluted by storm water or surface drainage, and in seeking a location for experiments upon the filtration of sewage, a supply of ordinary city sewage undiluted by storm water was sought, but no such locality in the State being available the Board found many advantages in locating the experimental station in the city of Lawrence, upon the north bank of the Merrimack River, where land owned by the Essex Company was placed at its disposal for the purpose.

To this place sewage is conveyed in a two and a half inch pipe of galvanized iron, from a point in the main sewer of the city about 1,000 feet above its outlet, and above the entrance of streams from the manufacturing establishments; this sewage from stores and from the dwellings of perhaps 10,000 people may reasonably be regarded as ordinary city sewage, similar during very dry weather to sewage separate from storm water, but during wet weather very much diluted by surface drainage.

The iron pipe follows the sewer to its outlet, and there rests upon the bed of the river for 3,000 feet, then extends 300 feet within the filtering grounds.

The filtering grounds comprise about two-thirds of an acre with surface from fifteen to twenty feet above the river in summer. The material of the field is fine sand, known as river silt, deposited by the river upon its banks at times of freshet.

Within this area the Essex Company had constructed in former years, for its own use, a building three hundred feet long, and about ten feet wide, and ten feet high, nearly all below the surface of the ground, lighted by windows in the roof.

Within this building was a drain, and above this a wooden flume about two feet wide and one foot high, resting on piles, two at every five feet of its length, and sloping in its length about one foot in one hundred feet. This flume is divided at each twenty-five feet of its length by a tight par-

tition, each section forming a basin twenty-five feet long, about two feet wide and one foot high, and containing between two and three hundred gallons. Each section is provided with an outlet by which its contents may be turned into the drain beneath.

Outside of the building, in the field, where the surface of the ground is seven and one half feet above the upper edge of this flume, opposite each of ten of the sections of twenty-five feet in length is placed a wooden tank, buried to its top.

These ten tanks were made of cypress, circular in plan, sixteen feet eight inches in diameter inside, at the bottom, seventeen feet four inches at the top, and six feet deep inside.

They were set with the bottom sloping four inches in its width toward the building, and the top of the staves cut level with the low side.

They rest upon mud sills and a bed of puddle, and before the sides were puddled in, the tanks were proved to be completely water tight.

From the lowest point in the bottom, a two-inch iron pipe, through the ground, conveys drainage from within the tank to the nearest section of the flume within the building.

In each tank fifteen feet in length of underdrain of horseshoe section, of about two square inches in area, is set half an inch above the bottom, and the floor covered with one layer of coarse gravel stones about one inch by two inches, this by another layer of smaller size, upon which follow layer after layer, decreasing in size to one eighth of an inch in diameter, and making a thickness of three and a half inches. This fine gravel is covered with very coarse mortar sand, with top surface level, three and one half inches deep in the middle of the tank.

Above this substratum the several tanks are filled as follows: —

Tank No. 1. Filled with five feet in depth of very coarse clean mortar sand, taken from a depth of six or eight feet.

Tank No. 2. Filled with five feet in depth of very fine, nearly white sand, taken from a pit below discoloration by weather.

Tank No. 3. Filled with peat, which is nearly all vegetable matter, but contains a little mud. The top of the peat bed which

had been cultivated was removed and the tank filled four feet with the undisturbed lower layers, and one foot of the original top layer put on top.

Tank No. 4. Filled with five feet in depth of river silt, being mostly a very fine sand, from the excavation made in setting tank No. 5.

Tank No. 5. Filled five feet deep with an excellent quality of brown soil taken from a garden which had been cultivated many years, and manured and put down to grass last spring.

Tanks No. 6, 7 and 8. Filled to be as near alike as possible, with three feet eight inches of coarse and fine sand and fine gravel. Ten inches of yellow sandy loam, and six inches of brown soil, in the same position as found on the river bank, where it was covered with a poor growth of pine trees.

Tank No. 9. Filled four feet three inches deep with a very compact sandy hard pan of clay, sand and gravel, from Prospect Hill, Lawrence, covered with nine inches of brown soil.

In each case the filtering material was thrown scattering into water which partly filled the tank.

After filling each tank to a height three inches below the top, a little sloping bank one foot wide was filled around the inside of each tank, of the same material as the upper layer of the filter, to prevent the liquid applied reaching the side of the tank too freely.

Tank No. 10 is for the present used for the measurement of the rain fall and the evaporation.

Within the building at a higher level than the top of the tanks are placed two measuring basins, into which the sewage is pumped, and by a scale of heights indicating gallons the quantity to be put upon each filter tank is noted, and this quantity is distributed by movable hose to either of five tanks from one measuring basin, and to the other five tanks from the other measuring basin. Similar scales indicating gallons, in the basins in the building below the filter tank outlets, serve to measure the effluent from each of the filters.

Samples of crude sewage from the upper measuring tanks, and of the effluent from the lower measuring basins, are daily submitted to chemical and biological analysis.

In the field beyond the filter tanks the area of about one-third of an acre is sloped in the direction from the line of

tanks about one foot in ten feet, and in the direction parallel with them about one foot in one hundred feet. This area is laid out in shallow drains to receive sewage for filtration, underdrains being placed sixty feet apart to catch samples of the effluent.

These underdrains are put at the depth of four feet, and slope like the surface, — one foot in ten feet, — being about fifty feet in length, opposite tanks Nos. 3 and 8, and opposite the space between Nos. 5 and 6.

Trenches were cut two feet wide and the bottom coated with two inches of puddling clay, plastered on a little lower in the middle where the two-inch drain tile was laid with open joints and surrounded with six inches in depth of gravel.

The surface drains are in the material of the field which for several feet in depth is a fine river silt, which freezes about as readily and compactly as clay. To guard against the interference of this hard freezing, shallow trenches, which follow the surface of the field in slopes, 1 foot in 30 feet, 1 foot in 50 feet, and 1 foot in 100 feet, were dug out one foot wide, with the bottom level of the same width, and of the following depths: No. 1, 6 inches deep; No. 2, 1 foot deep; No. 5, 3 feet deep; No. 6, $2\frac{1}{2}$ feet deep; and filled in to these depths with coarse mortar sand similar to tank No. 1.

Trench No. 7 was dug out $1\frac{1}{2}$ feet wide and 2 feet deep; and trench No. 8, 2 feet wide and $1\frac{1}{2}$ feet deep, and filled with the same sand. These trenches are filled with coarse sand of the different depths and widths, to determine how much of such material is necessary to prevent trenches in river silt from freezing, and preventing filtration in the coldest weather. These trenches have the surface of the sand about four inches below the level of the ground adjacent, except near their lower end, where in fifty feet it increases to ten inches below.

They are about five feet apart, and in length as follows: No. 1, 113 feet; No. 2, 152 feet; No. 3, 195 feet; No. 4, 221 feet; No. 5, 176 feet; No. 6, 218 feet; No. 7, 203 feet; No. 8, 177 feet.

Before applying sewage to the tanks and trenches it was thought best to see what effect these several filtering mate-

rials would produce upon drinking water, and at the same time to determine the limiting quantity that could be passed through a layer of each material five feet deep most completely underdrained.

With this in view arrangements were made with the Water Board of the city of Lawrence to supply the experimental station with water, free of cost to the State, the Board of Health communicating to the Lawrence Water Board such results of its experiments upon drinking water as may be of service to that Board.

The results of these experiments made to the present time are now given in detail for each tank: —

Filter Tank No. 1.

Filled with very coarse mortar sand. The tank contains about 9,500 gallons of sand which was thrown into water and left saturated a month, when the water which flowed out readily amounted to 1,200 gallons in one hour, and 1,750 gallons in one and one-half hours, after which the rapidity of flow gradually decreased, 2,100 gallons having flowed out in 14 hours and 2,220 gallons at the end of 72 hours when the rate of flow was six-tenths of a gallon in an hour.

About one-fifth of the cubic contents of the tank flowed out in two hours.

The drainage was continued one week, during which time 145 gallons of rain fell into the tank, 150 gallons of the effluent came from the gravel and underdrains, and the filtering material contained a little more than 2,000 gallons of air.

Sand similar to this in tank No. 1 has been examined and found to contain about 35 per cent. of air space when perfectly dry. It follows that at this time this tank of 9,500 gallons of sand contained 2,000 gallons of air and 1,325 gallons of water.

Into this was poured daily 136 gallons, or the equivalent of one inch in depth over the surface of the sand, of water drawn from the city service pipes from November 14 to November 20; then 408 gallons daily from November 21 to November 26; none added on November 27; 544 gallons daily from November 28 to December 6; 1,000 gallons daily

from December 7 to December 11; and 4,000 gallons daily from December 12 to December 16.

This water being applied with considerable care, to spread it over the surface, must have pushed before it a large part of the 1,325 gallons already in the tank, before it appeared at the outlet; how large a part we have not yet the means of determining with certainty. Probably it did not appear until 1,000 gallons had passed out, or until seven days after the first of the 136 gallons was applied. Comparing the quality of the water applied with that which flowed out after 1,000 gallons had passed after each change in quantity, we have given in the following table the mean result of the chemical analyses of applied water, and the effluent from this tank during the application of each of the quantities of water.

These results show a progressive improvement in the filtered water for the five weeks that the filter was in use, up to the end of filtering 1,000 gallons per day, and a slight decrease in percentage of impurities removed while 4,000 gallons per day were flowing through.

The general results at this tank to December 16 are: Removing the color completely; reducing the organic matter to $\frac{1}{2}$; reducing the free ammonia to $\frac{1}{4}$; reducing the albuminoid ammonia to nearly $\frac{1}{4}$; reducing the chlorine to $\frac{6}{7}$, and reducing the nitrates to $\frac{3}{4}$ of the amounts in the applied water.

From December 17 to 23 this tank was supplied with 230 gallons daily of effluent from tank No. 5, which is filled with garden soil, with the mean result given in the table.

The color was removed. The organic matter, which is the loss on gently igniting the solid residue on evaporation of the water, reduced to one-quarter and the ammonia to one-seventeenth of the applied water; the chlorine reduced from 0.45 to 0.24 and the nitrates unchanged.

From December 24 to December 30 this tank was again supplied with 4,000 gallons of city water per day, with nearly the same general result as when previously applied.

Tank No. 1. (Parts in 100,000.)

	No. of Analyses.		Residue on Evaporation.			Ammonia.		Chlorine.	Nitrogen as Nitrites and Nitrates.
			Total.	Loss on Ignition.	Fixed.	Free.	Albuminoid.		
		While applying 136 gallons of water daily, Nov. 14 to 20, —							
Applied water,	1	. . . .	4.40	1.15	3.25	.0034	.0144	.30	.020
Effluent, . .	1	. . . .	5.10	0.75	4.35	.0010	.0070	.36	.020
		While applying 408 gallons of water daily, Nov. 21 to 26, —							
Applied water,	1	. . . .	4.30	1.35	2.95	.0016	.0104	.28	.018
Effluent, . .	3	. . . .	3.75	0.85	2.90	.0008	.0059	.26	.014
		While applying 544 gallons of water daily, Nov. 28 to Dec. 6, —							
Applied water,	7	. . . .	4.29	1.39	2.90	.0020	.0137	.31	.018
Effluent, . .	3	. . . .	3.19	0.58	2.61	.0003	.0029	.27	.015
		While applying 1,000 gallons of water daily, Dec. 7 to 11, —							
Applied water,	4	. . . .	4.46	1.08	3.38	.0026	.0132	.33	.020
Effluent, . .	2	. . . .	3.12	0.62	2.50	.0002	.0027	.30	.016
		While applying 4,000 gallons of water daily, Dec. 12 to 16, —							
Applied water,	5	. . . .	4.30	1.42	2.88	.0026	.0134	.28	.019
Effluent, . .	3	. . . .	3.23	0.68	2.55	.0012	.0043	.24	.012
		While applying 230 gallons daily of effluent from Tank No. 5, Dec. 17 to 23, —							
Applied water,	4	. . . .	9.96	3.02	6.94	.0770	.0673	.45	.008
Effluent, . .	3	. . . .	4.33	0.72	3.61	.0009	.0077	.24	.008
		While applying 4,000 gallons of water daily, Dec. 24 to 30, —							
Applied water,	3	. . . .	4.08	1.07	3.01	.0033	.0143	.20	.010
Effluent, . .	4	. . . .	3.21	0.51	2.70	.0015	.0069	.23	.018

Filter Tank No. 2.

From 8,500 gallons of fine sand in this tank 650 gallons of water or seven and a half per cent. of the contents flowed out readily. Of this, 500 gallons flowed out in 22 hours and 150 gallons in 42 hours more.

After draining six days 830 gallons had flowed out and 145 gallons had been supplied by rain, leaving in the 8,500 gallons of sand 685 gallons of air.

The sand of this tank and the material of the other tanks to follow has not yet been examined to determine how much water can be added to saturate a perfectly dry mass of it, but it will for present purposes be assumed to be three-tenths of the whole mass, except in case of tank No. 3.

Three-tenths of 8,500 gallons gives us 2,550 gallons of water when saturated, but 685 gallons had been withdrawn, leaving in the tank 1,865 gallons of water and 685 gallons of air.

Into this were poured 136 gallons of city water daily, from November 14 to November 26; 272 gallons daily, from November 28 to December 11; and 1,000 gallons daily, from December 12 to December 18, after which sewage was applied. The mean results of the chemical examinations for each stage are given in the following table: —

TANK No. 2. (Parts in 100,000.)

	No. of Analyses.		Residue on Evaporation.			Ammonia.		Chlorine.	Nitrogen as Nitrites and Nitrates.
			Total.	Loss on Ignition.	Fixed.	Free.	Albuminoid.		
		While draining water from tank, Nov. 8 to Nov. 11, —							
Effluent, . .	3	. . . .	5.20	1.12	4.08	.0012	.0067	.33	.007
		While applying 136 gallons daily, Nov. 14 to Nov. 26, —							
Applied water,	2	. . . .	4.35	1.25	3.10	.0025	.0124	.29	.019
Effluent, . .	4	. . . .	3.70	0.80	2.90	.0015	.0048	.38	.007
		While applying 272 gallons daily, Nov. 28 to Dec. 11, —							
Applied water,	10	. . . .	4.36	1.26	3.10	.0023	.0136	.31	.019
Effluent, . .	5	. . . .	2.88	0.80	2.08	.0006	.0030	.32	.010
		While applying 1,000 gallons daily, Dec. 12 to Dec. 18, —							
Applied water,	6	. . . .	4.28	1.39	2.89	.0025	.0133	.28	.019
Effluent, . .	2	. . . .	2.35	0.57	1.78	.0002	.0024	.27	.013
		While applying 136 gallons of sewage daily, Dec. 19 to 23, —							
Sewage, . .	3	. . . .	37.03	18.63	18.40	.8093	.3250	3.17	.006
Effluent, . .	1	. . . .	3.90	1.55	2.35	.0058	.0044	.36	.020
		While applying 272 gallons of sewage daily, Dec. 24 to 30, —							
Sewage, . .	2	. . . .	41.70	20.20	21.50	1.5100	.6000	3.56	.006
Effluent, . .	3	. . . .	4.35	1.47	2.88	.0032	.0079	0.69	.006

The applied waters of each stage are compared with the effluent which came after 1,800 gallons had flowed out after the beginning of the application.

These results show a very decided improvement in the filtered water the longer the filter was used and the greater the quantity of water put on daily; the organic matter burned out decreasing from 0.80 to 0.57, and the sum of the ammonia from .0063 through .0036 to .0026, and the nitrates increased from .007 through .010 to .013.

The final results, which are the best, are with 1,000 gallons a day flowing through the tank and are: Removing the color completely; reducing the organic matter to $\frac{4}{10}$; reducing the free ammonia to $\frac{1}{12}$; reducing the albuminoid to $\frac{1}{6}$; leaving the chlorine unchanged; reducing the nitrates to $\frac{3}{4}$ of the amounts in the applied water.

City sewage was applied to tank No. 2 from December 19 to 23, at the rate of 136 gallons per day, when it was increased to 272 gallons per day.

The results are presented in the table, and up to the present time show an effluent which is chemically about as good as the city water which has been applied previously, but the chlorine and albuminoid ammonia have been increasing since the sewage began to come through, and further time is necessary before making a conclusion as to the continued action of this filter upon this quantity of sewage. The effluent is bright, clear and colorless.

Filter Tank No. 3.

From 8,500 gallons of muck 230 gallons flowed out in twenty-four hours, and 500 gallons in one hundred and seven hours, when the rate of flow was about two gallons per hour, but the amount of air left in the muck cannot be stated, because as the water flowed out the muck settled.

The water began to flow out November 9. Up to November 17, 136 gallons of water had been put on from the city main, and 334 gallons from rain, making 470 gallons applied. Eight hundred and twenty-six gallons had flowed out and near an inch in depth stood upon the surface; this with ninety-four gallons from rain, kept water upon the surface till November 26, when it disappeared, and the

surface was left to dry till December 3, from which date to December 13 fifty gallons per day were applied, but this accumulating on the surface was discontinued.

The quantity flowing through the tank has gradually decreased until it has become less than one gallon an hour, although the surface is continually covered with water.

The quality of the water flowing from this tank after the first two weeks has been nearly constant, and is expressed by the following mean of ten chemical examinations:—

Total residue on evaporation,	13.20
Loss on ignition,	3.07
Fixed,	10.13
Free ammonia,	.0058
Albuminoid ammonia,	.0239
Chlorine,	1.26
Nitrogen as nitrites and nitrates,	.017
Nitrites,	Present.

The applied water consisted of about 510 gallons of rain and 636 gallons of city water.

The color of effluent was less than that of applied water.

The organic matter is more than doubled.

The ammonias are higher than those of the city water, and lower than those of the rain water.

The chlorines are greatly increased, being four times those of the city water, but are growing less.

The nitrates have increased from .012 to .018, and in the latter half of the time have been about the same as those of the city water.

On the whole the effluent from this tank is not as good as the applied water, and the small amount that passes through renders this material of little value as a filtering material. This amount is but 1,800 gallons per day per acre, in excess of the average rain falling upon it.

From December 26, city sewage to the amount of twenty-five gallons has been applied daily, and when rain fell in sufficient quantity to cover the surface it has been bailed out; seventy-five gallons being taken out on December 29.

Up to the present time no effect of sewage is noticeable in the effluent, probably none has gone entirely through the filtering material.

Filter Tank No. 4.

From 8,500 gallons of river silt, 550 gallons of water flowed out in seventy-eight hours without appreciable settlement of the sand, although the surface cracked. The sand then contained about 550 gallons of air, and about 2,000 gallons of water. Into this was poured daily 136 gallons of water from November 14 to 26, and 272 gallons daily from November 28 to December 7.

On one of these days, December 1, when the temperature was 4°, the surface of this tank froze and prevented the passage of water. Outside of the tank river silt was found to be frozen to a depth of eight inches, or about equal to that of clayey hard pan.

Continued application of the water at temperature of about 40° on the following day caused the frozen surface to melt and let water through. To avoid stopping the experiments on this tank in still colder weather a change was made in the surface by excavating trenches, and filling them with the coarse sand, like that in tank No. 1. The outer trench was one foot from outside of tank, one and one half feet deep and two feet wide. The inner trench was five feet from the outside, two feet deep and one and one half feet wide, and in the centre was excavated and filled with the sand, a cylinder sixteen inches in diameter, and three feet deep. These trenches receive the water immediately below the surface, and enable a much larger quantity of water to be put upon this tank than formerly.

The maximum flow from the tank when 136 gallons were applied was fifteen gallons per hour. When 272 gallons were applied it was 24 gallons per hour before the change, and 65 gallons per hour after the change; and with 1,000 gallons per day the maximum flow was 110 gallons per hour.

After the change the amount of water left in the tank when drained, after 272 gallons were applied, was probably about 1,700 gallons. The 272 gallons were continued daily from December 8 to 11, and 1,000 gallons daily from December 12 to 18, then 136 gallons of sewage were applied daily from December 19 to 23, and 272 gallons of sewage from December 24 to 31.

The mean results of the chemical analyses for each quantity applied are given in the following table :—

TANK No. 4. (Parts in 100,000.)

	No. of Analyses.		Residue on Evaporation.			Ammonia.		Chlorine.	Nitrogen as Nitrites and Nitrates.
			Total.	Loss on Ignition.	Fixed.	Free.	Albuminoid.		
		While drawing water from tank, Nov. 11 to 14,—							
Effluent, . .	2	. . . .	8.20	1.15	7.05	.0031	.0083	.33	.009
		While applying 136 gallons of water daily, Nov. 14 to 26,—							
Applied water,	2	. . . .	4.35	1.25	3.10	.0025	.0124	.29	.019
Effluent, . .	4	. . . .	8.53	1.44	7.09	.0060	.0126	.39	.012
		While applying 272 gallons of water daily, Nov. 28 to Dec. 7,—							
Applied water,	7	. . . .	4.29	1.24	3.05	.0021	.0139	.31	.018
Effluent, . .	4	. . . .	7.37	1.30	6.07	.0099	.0084	.32	.014
		While applying 272 gallons daily, after change in surface of tank, Dec. 8 to 11,—							
Applied water,	3	. . . .	4.53	1.32	3.21	.0026	.0128	.30	.021
Effluent, . .	1	. . . .	5.80	1.40	4.40	.0090	.0080	.32	.030
		While applying 1,000 gallons of water daily, Dec. 12 to 18,—							
Applied water,	6	. . . .	4.28	1.39	2.89	.0025	.0133	.28	.019
Effluent, . .	4	. . . .	4.26	0.74	3.52	.0064	.0069	.24	.029
		While applying 136 gallons of sewage, Dec. 19 to 23,—							
Sewage, . .	3	. . . .	37.03	18.63	18.40	.8093	.3250	3.17	.006
Effluent, . .	1	. . . .	5.65	1.85	3.80	.0072	.0060	.63	.058
		While applying 272 gallons of sewage, Dec. 24 to 31,—							
Sewage, . .	2	. . . .	41.70	20.20	21.50	1.5100	.6000	3.56	.006
Effluent, . .	3	. . . .	9.27	2.43	6.84	.0089	.0083	2.42	.037

The effluent from the original tank was not as good as the applied water, nor did it improve after the change, while 272 gallons were applied.

Before and after the change when 272 gallons were applied the results were :—

The removal of color; a considerable increase in the fixed solids; a slight increase of organic matter; a large increase in the free ammonia, with a decrease in the albuminoid ammonia, leaving the sum of the ammonias ten to fifteen per cent. greater; the chlorine unchanged; and the nitrates at first less became greater than in the applied water. While 1,000 gallons were applied to the changed material the effluent improved and became better than the applied water, and continued improving, while the lesser quantity of 136 gallons daily was passing through after the application of sewage to the top and before it reached the bottom. The sewage applied on December 19 gave the first indication of reaching the outlet on December 27 by a slight increase in the chlorine from 0.23 of the previous days to 0.29, but on December 29 it became certain by the increase of the chlorine to 0.63, of the nitrates from .032 to .058, and of the organic matter from 0.87 to 1.85.

The effluent from sewage has to the present time continued to increase in impurities, and on January 5 the organic matter was twenty per cent.; the free ammonia one half of one per cent.; and the albuminoid ammonia one and one quarter per cent. of that of the applied sewage. The chlorine had increased to three quarters of that of the sewage, and the nitrates had increased sevenfold.

Filter Tank No. 5.

From the 8,500 gallons of garden soil, 400 gallons of water drained out in seventy-four hours when the rate of flow became one and one half gallons per hour.

There was slight settlement and some cracking of surface, which cracks were afterwards filled with soil. This tank is regarded as then containing 2,100 gallons of water.

There were applied 136 gallons of city water daily from November 14 to 26, and 272 gallons were applied daily for

a week, after which some accumulated on the surface and the quantity was gradually reduced to 230 gallons, which was continued to December 23. The water evidently dissolved impurities from the soil in increasing quantities till December 9, after which the quantities remained nearly constant.

The mean results of the chemical analysis for each quantity applied are given in the following table : —

TANK NO. 5. (Parts in 100,000.)

	No. of Analyses.		Residue on Evaporation.			Ammonia.		Chlorine.	Nitrogen as Nitrites and Nitrates.
			Total.	Loss on Ignition.	Fixed.	Free.	Albuminoid.		
		While drawing water from tank, Nov. 12, —							
Effluent, . .	2	. . . .	11.42	1.75	9.67	.0019	.0198	.45	.003
		While applying 136 gallons of water daily, Nov. 14 to 26, —							
Applied water,	2	. . . .	4.35	1.25	3.10	.0025	.0124	.29	.019
Effluent, . .	3	. . . .	12.16	3.23	8.93	.0797	.0647	.64	.005
		While applying from 272 gallons to 230 gallons daily, Nov. 28 to Dec. 23,—							
Applied water,	18	. . . .	4.28	1.30	2.98	.0024	.0134	.29	.018
Effluent, . .	13	. . . .	10.51	3.17	7.34	.0800	.0636	.45	.007

The color of the effluent, slight at first, grew deeper as the experiments continued, but not as deep as that of the applied water. The fixed and volatile solids were both increased nearly two and a half times that of the applied water. The free ammonia was increased to thirty times and the albuminoid ammonia five times that of the applied water.

The chlorine was doubled and the nitrates decreased to one third, but as the use continued the chlorine at first large grew less, approaching that of the applied water, and the nitrates, at first small, increased, to be nearer that of the applied water.

Filter Tank No. 6.

From 8,500 gallons of material consisting of about 6,236 gallons of gravel and sand, 1,414 gallons of yellow subsoil and 850 gallons of brown soil, about 950 gallons of water flowed out in forty hours, ending with a rate of flow of four gallons per hour, which rate was rapidly decreasing. The tank then contained 950 gallons of air, which was one-ninth of its volume, and probably 1,600 gallons of water. Into this was poured daily 136 gallons of water from November 16 to 26, then 272 gallons from November 28 to December 14. On December 15 the six inches of soil was removed from the tank and the water applied directly to the surface of the yellow subsoil.

The mean results of the chemical analyses for each quantity applied are given in the following table : —

TANK NO. 6. (Parts in 100,000.)

	No. of Analyses.		Residue on Evaporation.			Ammonia.		Chlorine.	Nitrogen as Nitrites and Nitrates.
			Total.	Loss on Ignition.	Fixed.	Free.	Albuminoid.		
		Water drawn before applied water, —							
Effluent, . .	1	. . . .	5.45	0.95	4.60	.0010	.0066	.84	.000
		When 136 gallons were applied daily, Nov. 16 to Nov. 26, —							
Applied water,	2	. . . .	4.35	1.25	3.10	.0025	.0124	.29	.019
Effluent, . .	2	. . . .	5.17	0.85	4.32	.0007	.0041	.75	.001
		When 272 gallons were applied daily, Nov. 28 to Dec. 14, —							
Applied water,	13	. . . .	4.40	1.31	3.09	.0022	.0134	.31	.019
Effluent, . .	7	. . . .	3.68	0.66	3.02	.0005	.0030	.32	.001
		When 272 gallons were applied daily to subsoil, Dec. 15 to 29,—							
Applied water,	7	. . . .	3.99	1.20	2.79	.0029	.0133	.26	.015
Effluent, . .	7	. . . .	3.01	0.59	2.42	.0004	.0035	.23	.006

These results show the water much improved from the first, and an increased improvement with continued use. With 136 gallons applied daily the color was entirely removed; the organic matter was reduced from 1.25 to 0.85; the free ammonia was reduced from .0025 to .0007, and the albuminoid ammonia from .0124 to .0041. The chlorine was increased from .29 to .75, and the nitrates decreased from .019 to .001.

While applying 272 gallons the efficiency of the filter increased, reducing the impurities generally 25 per cent. more, and bringing the chlorine to agree with that of the applied water. After removing the soil from the tank, and applying the water directly to the subsoil for two weeks, the remaining material gave results nearly identical with those obtained with the soil, showing in this case that the soil was of no advantage or disadvantage in filtering this drinking water.

On December 30, the ten inches of yellow subsoil being removed, water is now applied directly to the surface of the sand and gravel.

Filter Tank No. 7.

This tank, filled with similar material to No. 6, when saturated yielded 1,200 gallons in forty hours without apparent settlement, ending with a rate of flow of about three gallons per hour, and estimated as then containing 1,300 gallons of water. Into this 8,500 gallons of material containing about 1,200 gallons of air and 1,300 gallons of water, 272 gallons of water were applied daily from November 16 to November 26; 408 gallons daily were put on after November 28, when the tank would receive it, but owing to frost a part of the time and silting up of the surface the quantity applied was less. From November 28 to December 7 it averaged 362 gallons; from December 8 to 14, 364 gallons, and from December 15 to 27, 312 gallons.

The mean results of the chemical analyses for each stage are given in the following table:—

TANK NO. 7. (Parts in 100,000.)

	No. of Analyses.		Residue on Evaporation.			Ammonia.		Chlorine.	Nitrogen as Nitrites and Nitrates.
			Total.	Loss on Ignition.	Fixed.	Free.	Albuminoid.		
		While applying 272 gallons daily, Nov. 16 to 26, —							
Applied water,	2	. . . .	4.35	1.25	3.10	.0025	.0124	.29	.019
Effluent, . .	3	. . . .	4.55	0.78	3.77	.0005	.0054	.41	.001
		While applying about 362 gallons daily, Nov. 28 to Dec. 7, —							
Applied water,	7	. . . .	4.29	1.24	3.05	.0021	.0139	.31	.018
Effluent, . .	5	. . . .	3.74	0.64	3.10	.0003	.0024	.33	.001
		While applying about 364 gallons daily, Dec. 8 to 14, —							
Applied water,	6	. . . .	4.53	1.39	3.14	.0023	.0129	.31	.020
Effluent, . .	4	. . . .	3.10	0.64	2.46	.0003	.0029	.29	.001
		While applying about 312 gallons daily, Dec. 15 to 27, —							
Applied water,	6	. . . .	3.93	1.20	2.73	.0029	.0132	.24	.016
Effluent, . .	6	. . . .	3.07	0.42	2.65	.0005	.0031	.23	.001

The result, generally stated, is a decided improvement of the water from the first, with increased improvement for a month, after which the effluent remained nearly constant with the following relation to the applied water: The color was completely removed; the fixed solids were reduced slightly; the organic matter from 1.20 to 0.42; the free ammonia reduced from .0029 to .0005, and the albuminoid ammonia from .0132 to .0031; the chlorine unchanged, and the nitrates reduced from .016 to .001.

Filter Tank No. 8.

This tank, filled with material similar to that of No. 6 and of No. 7, when saturated yielded 1,150 gallons in 40 hours without apparent settlement, ending with a rate of flow of about three gallons per hour.

Into this 8,500 gallons of material containing about 1,150 gallons of air (and probably 1,400 gallons of water), 408 gallons of water were poured daily from November 16 to 26; then an average of 475 gallons per day from November 28 to December 7, after which an effort was made to keep the tank continually covered with water, and from December 8 to 16 the average quantity flowing through was 564 gallons per day. On December 16 a faucet was attached to the outlet and the stream regulated so that no air should enter the tank through the drain pipe.

The mean results of the chemical analyses are given in the following table: —

TANK NO. 8. (Parts in 100,000.)

	No. of Analyses.		Residue on Evaporation.			Ammonia.		Chlorine.	Nitrogen as Nitrites and Nitrates.
			Total.	Loss on Ignition.	Fixed.	Free.	Albuminoid.		
		While applying 408 gallons of water daily, Nov. 16 to 26,—							
Applied water,	2	. . . .	4.35	1.25	3.10	.0025	.0124	.29	.019
Effluent, . .	2	. . . .	3.85	0.42	3.43	.0006	.0046	.34	.000
		While applying about 475 gallons of water daily, Nov. 28 to Dec. 7,—							
Applied water,	7	. . . .	4.29	1.24	3.05	.0021	.0139	.31	.018
Effluent, . .	4	. . . .	3.37	0.57	2.80	.0004	.0029	.31	.003
		While applying about 564 gallons of water daily, Dec. 8 to 16,—							
Applied water,	10	. . . .	4.36	1.23	3.13	.0025	.0133	.30	.019
Effluent, . .	3	. . . .	2.92	0.40	2.52	.0002	.0024	.26	.005
		Applying about 446 gallons daily, with air excluded, Dec. 17 to 31,—							
Applied water,	5	. . . .	3.99	1.11	2.88	.0031	.0134	.20	.011
Effluent, . .	9	. . . .	2.92	0.35	2.57	.0006	.0034	.24	.006

For the first month there was a continually increasing improvement in the quality of the effluent. The color was entirely removed. The organic matter that could be burned out of the applied water being 1.24 became in the effluent 0.42, 0.57 and 0.40 successively. The free ammonia from .0025 became .0006, .0004 and .0002; and the albuminoid ammonia from .0132 became .0046, .0029 and .0024. The chlorine from 0.30 became 0.34, 0.31 and 0.26, while the nitrates from 0.19 in the applied water became successively, .000, .003 and .005.

After air was excluded from the top and bottom of the filtering material the ammonias slowly became a little higher, but the change has been very slight in the two weeks of the trial.

Filter Tank No. 9.

This tank filled with 7,200 gallons of clay, sand and gravel such as forms the hard pan of many drift-hills in Eastern Massachusetts, covered with 1,300 gallons of brown soil, discharged 400 gallons of water in one month. No water was put upon the surface because it was kept continually covered by rain. The first 200 gallons had a slight tinge of color. Its volatile solids amounted to 4.50 and fixed solids to 14.63; the free ammonia to .0047 and albuminoid ammonia to .0129, chlorine to 2.33 and nitrates to .003.

The last 200 gallons had no color. The volatile solids amounted to 4.75; the fixed solids to 13.79; the free ammonia to .0013; the albuminoid ammonia to .0064; the chlorine to 2.88 and the nitrates to .003.

This appears to be a result slowly changing for the better.

The analysis of the principal rain which fell in this month showed it to have .0390 of free ammonia, .0124 of albuminoid ammonia, .04 of chlorine and .002 of nitrates, but it is not certain that any of this rain water reached the outlet of the tank.

It is important to know the characteristics of this material as affecting the water of wells, but it allows so little water to pass through that it has no value as a filter upon which to apply sewage. After draining one and one-half months,

and being kept covered with water, the rate of flow is but twelve gallons per day, which is about seven-tenths of the average rainfall upon this area.

On December 30 a hole was cut in the surface of this tank nine inches through soil and six inches into wet puddling material, and a wooden conductor six inches square inside and four feet long, set vertically in the hole and filled around tight with the material excavated and a further bank of soil built up around it. This box stands fifteen inches into the material of the tank and the top stands two feet nine inches above the surface.

Since December 30 this box has been supplied with ten gallons of sewage daily, that the effluent may show the effect of sewage draining constantly through such material into a well.

The water applied to the tanks and the effluent have been subjected to careful microscopical examination by Mr. G. H. Parker of Cambridge with the following general result: —

Of the twelve plant forms and one animal form represented by many of each kind found in the applied water, none have been found in the effluent.

In the effluent from most of the tanks have been found a very few representatives of two plant forms and in that from one tank of three plant forms and one animal. The plants found are characteristic of ground waters and are supposed to act as purifiers by living upon the organic matter.

Dr. Edward K. Dunham, bacteriologist of the Board, has taken samples of the applied water and the effluent from each of the filters every other day during the month of December, and determined the number of bacteria in each sample by culture plates.

He is not yet ready to report upon the difference of species of those applied and those coming from the filters.

The following table gives the average number of viable bacteria in one cubic centimeter of water taken from each source during the month of December: —

Applied water,	68	No. 5,	49
No. 1,	20	6,	17
2,	20	7,	18
3,	36	8,	55
4,	21	9,	107

The number of bacteria found in a cubic centimeter of the applied sewage averaged 193,000. On January 3 the effluent from tank No. 2 contained 6,618 and on January 5 over 10,000; and the effluent from tank No. 4 on January 3 contained 95 and on January 5 a great increase; and some of the species from the effluent are the same as in the sewage.

Recommendations.

The Board recommends the continuation through the summer and fall of the monthly examination of all of the drinking waters of the State which are subject to pollution by sewage or by low stages of ponds and streams, which owing to the unusual rainfall of the past summer were not then found in an ordinary summer condition, and the continuation of the analysis of such other waters at intervals as may appear desirable.

The Board also recommends the active prosecution of the experiments upon the purification of sewage, recently commenced, through the coming year, and the prosecution of such additional investigations as may become necessary to properly interpret the results of the examination of water and of sewage.

For these purposes and to make the necessary investigations in order to advise cities, towns, corporations and individuals in regard to the best method of assuring the purity of intended or existing water supplies, and the best method of disposing of their sewage, and to carry out the other provisions of chapter 274, the Board estimates that the sum of $25,000 will be required.

H. P. WALCOTT,
T. K. LOTHROP,
H. F. MILLS,
E. U. JONES,
J. H. APPLETON,
F. W. DRAPER,
T. C. BATES,
State Board of Health.

REPORT OF THE CHIEF ENGINEER.

To H. P. Walcott, M. D., *Chairman State Board of Health.*

Sir: — Herewith is submitted a report for the year ending Dec. 31, 1887, of work done by the engineering department of the Board in compliance with the provisions of chapter 274, Acts of 1886.

The main work of this department during the year may be divided into two classes: (1), the examination of proposed plans or schemes of water supply or sewerage submitted by the various cities and towns; (2), the examination of existing water supplies and inland waters of the State with reference to their purity. Much time has also been devoted to work in connection with chapter 95 of the Resolves of 1887, relating to the disposal of the sewage of the Mystic and Charles River valleys, of which no report will be made here.

The engineering force employed at the beginning of the year has been increased by the addition of two assistants to the permanent force. Other temporary assistants have been employed from time to time as their services were needed, chiefly on work connected with water examinations.

Examination of Proposed Plans of Water Supply and Sewerage.

Under the provision that all city and town authorities and corporations shall submit to the Board for its advice outlines of their proposed plans and schemes in relation to water supply and sewerage, many plans have been submitted. These cases and the action taken upon them are described in the accompanying report of the Board.

Following the established policy of your Board, I have made careful examinations of the location of proposed works of water supply and sewerage, and of such other localities in the vicinity as it seemed necessary to consider in order to advise as to the most appropriate source of water supply, or the best method of disposal of the sewage. In addition to these examinations all available information relating to the project has been gathered as a basis for a written report to your Board. During the year seven

such reports have been made relating to water supply and eleven relating to sewerage.

In addition to these examinations and reports, four cases have been specially submitted to Mr. Joseph P. Davis, the consulting engineer of the Board, who has made an examination and has also reported in writing. In most of the other cases he has considered the schemes in a more general way and has furnished advice verbally.

Some of the cases presented during the year have been very important, and have required an extended investigation to develop the facts required as a basis for sound advice. Among these may be mentioned the application of the cities of Boston, Chelsea and Somerville, and the town of Everett with reference to a water supply from the Shawsheen River, — a subject which required more than two months of steady work of the office force for its investigation, — and the application of the city of Brockton for advice as to the best method of disposing of its sewage, which required many days to be spent in and about that city, aided by its engineer, to determine as well as could be without actual surveys of each place, the best one for the disposal of the sewage upon land.

In the case of the city of Boston and the associated municipalities, which, as they are all supplied by the city of Boston with water from the Mystic works, I will call the Boston Water District, the first question submitted to your Engineer was in regard to the length of time the present sources of water supply, when fully developed, would serve Boston alone, or this whole district.

This was in either case a problem of three principal elements.

1. The population to be supplied.
2. The quantity of water to be allowed per inhabitant.
3. The capacity of the sources when developed.

In considering the first element of the problem, tables and diagrams were prepared showing the population from 1810 to the present time of the present territory of Boston; of the Boston Water District; of the territory of Boston proper, excluding all annexation, and consequently East and South Boston; of the territory in 1865, prior to the annexation of Roxbury, Dorchester, West Roxbury, Charlestown and Brighton; and of the Metropolitan District, comprising all cities and towns within a limit of about nine miles from the State House.

The past experience of the first two districts indicated a somewhat definite law governing the rate of increase, and was thought to be the best basis for future estimates. The others were con-

sidered to show the relations of the first two to the whole Metropolitan District and the effect of restricted territory upon the future rate of growth.

The future population as estimated was much smaller than any previous estimates that have been made in connection with the Boston water supply, either by those favoring or opposing the addition to it of the Shawsheen River.

It has been customary to estimate the growth of cities by percentages of increase in a given time, and to consider these percentages as somewhat nearly constant. This is what might naturally be expected if the increase in population was wholly due to the excess of births over deaths; but in Boston and the Boston Water District, this rule does not appear to apply, since the growth in each five-year period from 1840 to 1885 was approximately constant in *numbers* and not in *percentages*. This result is due, in part, to the relation of emigration to immigration, and to the encroachment of the business upon the residential districts, taken in connection with the somewhat limited area of the latter. I refer to this area as being limited, not because it would not hold the whole growth of the Metropolitan District for many years, but because there is a much larger area near the city, which offers nearly equal attractions to those engaged in business in the city.

The effect of limited area in decreasing the rate of growth is strikingly shown when the population of Boston proper (excluding all annexation) is examined. In 1850 its population was 113,721; in 1855, 126,296, an increase of 12,575 in five years. From 1880 to 1885 the increase in five years was but 63. In the present territory of Boston the rates of increase, during the same five-year periods, were respectively 33,920 and 27,554; while in the Metropolitan District, outside of Boston, the corresponding figures were 21,040 and 37,214. These figures indicate that the slower rate of growth of Boston is due, largely, to its limited territory, the suburban municipalities absorbing a large share of the growth.

The possibility of the annexation of more territory was considered, but it was found impossible to predict its occurrence or its effect; some of the places suitably situated for annexation having a limited water supply, and others an ample supply for a long time in the future.

The second element in the problem, namely, the quantity of water to be allowed per inhabitant, was one not easily answered. In the large cities of this country, from 61 to 154 gallons are used daily. Boston used 66 gallons in 1870, 91 gallons in 1883, and 74 gallons in 1886. On the last date measures for the restric-

tion of waste were in force. Of the large cities, the smallest consumption, 61 gallons, is in Brooklyn, N. Y., and it contrasts more strongly with the 74 gallons used in Boston, when it is considered that systematic measures to restrict waste are in force at the latter place and not at the former. A very little consideration of the subject shows one important difference in the conditions of the two places. In Boston, in addition to the inhabitants, a large number of people coming from the suburbs use the city water during the day, while in Brooklyn the reverse is true. Both Boston and Brooklyn have adopted the policy of measuring water sold to large consumers ; yet, from the reports of the two places, it was found that the metered water in the former place was equivalent to 18 gallons daily, per inhabitant, while in the latter it was only one gallon. Some of the large users of water, such as hotels and steam railroads, in a business centre like Boston, are found only in limited numbers in a city like Brooklyn, occupied chiefly by dwelling-houses. Correspondence with the Brooklyn authorities elicited the fact that many of the large consumers of water in that city had private supplies drawn from the ground, a thing which is not often practicable in Boston. Examinations of this kind showed that the legitimate present and future consumption of water in Boston could not properly be based, to any great extent, upon the experience of other cities, and it was, consequently, necessary to study carefully the present legitimate use of water in Boston, and its increase in the past. I will not refer to this portion of the investigation in any detail, but will mention that it was a very careful one, and it showed that while the present consumption of water in Boston could, after a term of years, be materially diminished by the business-like application of known methods of restricting waste, yet there was a legitimate *increase* in the amount of water used per inhabitant, which would probably cause the legitimate *use* to rise as high as the present consumption at the end of about thirty years.

The third element of the problem — the capacity of the sources when developed — could be more accurately answered than ever before, because of extended surveys, then about completed, made by the city of Boston for the purpose of ascertaining the capacity and cost of storage reservoirs required to develop these sources. With these new data, and the records of the very dry years of 1880 and 1883, the result was obtained that the Sudbury and Cochituate sources would yield for the purposes of the city water-supply fully 50,000,000 gallons per day. This quantity was based upon the record of years so much dryer than any other in the history of the Boston Water Works, that it did not seem

necessary to make further allowance for the occurrence of two such years in succession, or for the occurrence of still dryer years, particularly as many years would elapse before the consumption of water would approach this quantity, and there would then be further experience to draw from.

Having drawn from these three elements of the problem the solution that the two sources mentioned (the Mystic being excluded) would probably supply Boston until 1912, and the Boston Water District until 1926, estimates were made of the probable and comparative costs of supplying for a term of years, with water from the Shawsheen or from the Sudbury and Cochituate works, the district now supplied with water from the Mystic works; the results being very favorable to the substitution of the Sudbury and Cochituate sources.

Examinations of Water Supplies and Inland Waters.

An appropriation providing for a comprehensive examination of the water supplies and inland waters of the State was made by the Legislature April 25, 1887. The work was begun soon after this date.

These examinations consist chiefly of monthly analyses of water from all the water supplies of the State, and of the more important rivers and other inland waters, supplemented at varying intervals by the examinations of a bacteriologist, and of a biologist who examines the grosser forms of microscopic life in the waters.

It has been the duty of your Engineer in connection with this work to make himself familiar with the various water supplies of the State; to determine under the general direction of your Board where samples of water should be taken; to arrange for their regular and systematic collection, and to gather information about all physical characteristics of the different water supplies, such as temperatures, volumes flowing in the streams, heights of water in the reservoirs, etc.

The results of the chemical and other examinations of the waters, when reported to the Board, have been in the custody of your Engineer, who has carefully studied them with the view of determining from his own stand-point in which directions new examinations could profitably be instituted, or those being made extended, diminished or discontinued.

At the beginning of the work, which has thus been outlined, the following circular and blank for returns were prepared: —

OFFICE OF STATE BOARD OF HEALTH,
13 BEACON STREET, BOSTON, May 23, 1887.

To ——— ———.

The State Board of Health intends to make monthly analyses for the ensuing year of waters used for domestic supplies within the State, and, in connection therewith, desires to obtain general information respecting the several water supplies. It, therefore, requests that you will send such printed information as you can; particularly reports describing the construction of your works, the occurrence of any unusual tastes, or growths of vegetation in or upon the water, or any general disease affecting the fish in the streams, ponds and reservoirs.

An answer is requested to such of the questions in the accompanying blank as are applicable to your works.

The library of the Board now contains the reports mentioned below.

Respectfully yours,

F. P. STEARNS,
Engineer State Board of Health.

COMMONWEALTH OF MASSACHUSETTS,
STATE BOARD OF HEALTH.

Please fill out such portions of this blank as are applicable to your works, and forward to F. P. Stearns, Engineer State Board of Health, 13 Beacon Street, Boston.

Some of the blanks have been filled from information now in the possession of the Board: please correct if wrong.

DATE, ——— ——— 188 .

1. Name of city or town.
2. Population, 1885.
3. Date when works were built. (If not all built at one time, state what additions were made, and when.)
4. By whom are works owned?
5. Source or sources of water supply.
6. Area of water-shed supplying such source or sources.
7. General geological and topographical character of the water-shed.
8. Mode of supply, whether by gravity or pumping, and whether distributing reservoir or tank is used.
9. General description of storage and distributing reservoirs, — natural or artificial, how constructed, area of water surface, capacity, character of bottom, amount of shallow flowage, etc.
10. Does all water pumped go through the distributing reservoir or tank?
11. What portion of the water pumped goes into the distributing reservoir?
12. Whether or not the water is delivered into the distributing reservoir at one side and drawn out at the other.
13. Number, kind, size and depth of wells used as sources of water supply.

14. Describe filter galleries or basins, and connections, if any, with stream, pond or reservoir.
15. Average daily capacity of works in dry year.
16. Daily average consumption.
17. Number of persons using the water.
18. Is water supplied to any one outside of your town or city?
19. Material of distributing mains.
20. Material of service pipes.
21. Does the water supply receive sewage, drainage from factories (mentioning kind), or other pollutions?
22. If there have been any bad tastes in the water, or excess of vegetable growth, or if the fish have been generally affected, and such occurrences are not fully described in printed reports, please describe the same and the remedy adopted, if any.
23. Have analyses of water from the present source been made? By whom? When? If not given in printed reports, please furnish copy of same.
24. Have records of the temperature of the water been taken in the past? If not printed, will you furnish copies if blanks are sent?
25. Will you keep records of the temperature of water in the future, if a thermometer and blanks are furnished?
26. Will you furnish samples of water for analysis each month, and forward at stated times by express, if bottles are supplied?
27. To whom shall future correspondence be addressed?
28. Name and address of collector of samples.
29. Name of Express Co.
30. Name of person furnishing this information.

Beginning the first of June, 1887, every public water supply in the State was visited and examined by your Engineer, or one of his assistants; places for taking samples of water were chosen, and the methods to be followed were explained to those who were to take them. Arrangements were also made for having daily records of the temperature of water taken at many places and sent monthly to this office.

From these returns it is found that all of the twenty-three cities in the State, and 103 out of a total of 327 towns, are wholly or in part provided with a public water supply.* This number excludes several towns in the western part of the State, where a limited number of families are supplied through a small pipe, by some individual or company, from a spring or stream on the neighboring hills; also others, where water is pumped from a manufac turing establishment to the dwellings of the operatives in the vicinity.

* Four towns, for which water-works are being constructed and are so nearly finished that they will be in operation the greater part of the coming year, are included in this and subsequent statements.

In Table No. 1 the number of cities or towns, having or not having public water supplies, are classed by each 500 of population, up to 6,000, according to the census of 1885. All places having a population of 6,000 or more, which includes all of the cities, now have a public water supply.

TABLE NO. 1.

POPULATION.	No. of places of given population having a public water supply.	Total population of places in preceding column.	No. of places of given population not having a public water supply.	Total population of places in preceding column.
Under 500	1	451	22	7,530
500–1,000	3	2,437	69	52,751
1,000–1,500	4	5,346	39	47,086
1,500–2,000	8	13,559	33	57,305
2,000–2,500	10	22,057	21	47,233
2,500–3,000	5	14,254	18	49,706
3,000–3,500	2	6,155	8	25,534
3,500–4,000	13	49,441	6	22,598
4,000–4,500	12	51,763	5	21,318
4,500–5,000	7	33,312	1	4,555
5,000–5,500	3	15,633	1	5,436
5,500–6,000	4	23,036	1	5,711
Above 6,000	54	1,357,934	–	–
Totals,	126	1,595,378	224	346,763

From the totals given in this table it will be seen that although but few more than one-third of the whole number of cities and towns in the State have a public water supply, yet the total population of the places supplied represents 82 per cent. of the population of the State. This estimate of population represents the whole number of persons in the municipalities supplied, and is consequently somewhat, though not very much, in excess of the number of persons who can avail themselves of a public supply. By further examination of the table it will be observed that there are but three towns having a population exceeding 4,500 that are not

supplied, and that where the population exceeds 3,500, the majority are supplied, while below this limit the reverse is true.

There are some important towns where the supply is limited to but one of several villages.

There are in the State 123 sources of public water supply, counting as a source each separate system of water works, and also each of the sources used in connection with any particular system, when essentially different in character. This does not agree exactly with the number of municipalities supplied, since in many cases a city, town, or company supplies several places, while in others a city or town has several sources of supply.

To indicate the nature of the sources, they may be divided into fifty supplying ground water, and seventy-three supplying surface water. Further classification of the sources may be made as follows:—

Ground-water Sources.

Springs,	16
Large wells,	16
Tubular wells,	7
Filter galleries,	7
Filter basins,	4
Total,	50

Surface-water Sources.

Artificial storage reservoirs,	36
Natural ponds,	32
Streams,	5
Total,	73

The line of separation between the different classes is somewhat indefinite. A filter gallery or well on the banks of a stream may each furnish water of identically the same character, while another well may furnish the water of a natural spring which it has replaced. Natural ponds by having their level raised may flow extensive meadows, and so become less satisfactory reservoirs than those that are wholly artificial. Tubular wells are frequently sunk in the bottoms of large wells or filter basins with the view of increasing the supply of water; and in other ways the classification is somewhat complicated, yet it furnishes a fair idea as to the sources from which the water supply of the State is obtained.

The cities having a population of more than 25,000 each, thirteen in all, get their supply from surface sources. Of the cities and large towns having a ground-water supply may be mentioned the following:—

City or Town.	Population in 1885.
Newton,	19,759
Waltham,	14,609
Newburyport,	13,716
Quincy,	12,145
Woburn,	11,750
Milford,	9,343
Brookline,	9,196
Hyde Park,	8,376

In Table No. 2 the various water supplies are classified by dates. The dates given are those when a modern public water supply was first introduced into a city or town.

TABLE NO. 2.

YEARS.	Increase in number of places supplied during the given time.	Increase in number of places supplied per year.
Previous to 1850,	6	–
1850–1859,	4	0.4
1860–1869,	10	1.
1870–1874,	29	5.8
1875–1879,	15	3.
1880,	4	4.
1881,	6	6.
1882,	3	3.
1883,	6	6.
1884,	7	7.
1885,	18	18.
1886,	5	5.
1887,	13	13.
Total,	126	–

This table shows the activity in water-works construction since 1870. Before that time the total number of municipalities supplied was twenty, or less than one-fifth of the present number. Nearly one-half of the whole number have obtained their supply

since 1880. The table takes no account of the many important additional supplies provided in many cases.

Of the 23 cities in the Commonwealth, 20, having a total population of 1,030,282, own their water works; while 3, having a total population of 57,214, are wholly supplied by private companies.

Of the 103 towns having a public water supply, 50, having a total population of 285,086, are supplied from their own works, and 53, having a total population of 222,796, by private companies. In this classification no account is taken of secondary supplies of small importance which exist in many places. The total population of the cities and towns owning their own works is 1,315,368, against 280,010 for those supplied by private companies.

About 200 samples of water collected from the existing water supplies of the State, and from 36 places on 17 rivers and ponds, are received monthly at the laboratory, in addition to a varying number collected as occasional specimens from other places or in connection with special investigations of new sources or existing works. Daily records of the temperature of the water at 50 places, and of the heights of water and other information needed to make an approximate estimate of the amount flowing in the rivers at 19 places, are taken by water-works and mill superintendents, or special observers, and are forwarded monthly to this office.

Schedules are prepared each month to show the day on which each sample of water should be collected, and are so arranged that the samples will reach the laboratory at a nearly uniform rate during the first five week-days of each week, in order to permit them to be analyzed promptly when received. The schedules are also arranged so that waters having some relation to each other shall be collected on the same day or, in the case of rivers, after such an interval of time as will allow the water to flow from one sampling place to another.

The willing co-operation of the water-works superintendents and others, and their readiness to collect and forward samples of water and to take such observations as we have desired, have added greatly to the value of the work done and have decreased the labor of this department; yet the tabulation and examination of the analyses and returns, the occasional visits to the different water works for further information or to collect samples, the special investigations made, and the very large amount of correspondence necessarily incident to such work, together with other work not connected with the water examinations, have kept the force employed in this office extremely busy.

In arranging in the beginning where samples of water should be taken it was the aim to get them in such a way that the chemical analyses would not only furnish a standard for future comparisons, but that they should show in addition general laws affecting the purity of water supplies. With this in view samples were taken of ground waters from filter galleries, wells and basins, and of surface waters in neighboring ponds or streams, to determine the effect of such filtration as might take place; other samples were taken to show the effect of storing ground or surface waters in open distributing reservoirs or in open or closed water towers; others the effect of continuous filtration through a thin layer of sand or gravel; others the comparative quality of water taken from the surface, mid-depth and bottom of a deep reservoir; others a comparison between water entering a storage reservoir and after standing in it; and others the effect of aeration caused by the flow down a long steep brook of water previously stored in a reservoir.

Many results have already accumulated, and an examination of them indicates that in addition to the great fund of scientific knowledge which they will furnish, much of practical value to those designing and superintending water works may be learned from such comprehensive work.

It is not proposed at this time, when the series of examinations of the waters is incomplete and all seasons of the year have not been included, to make any extended statement of the results found; some, however, are so well indicated and so important that it seems desirable to report them as they now appear.

When the first filter galleries were built beside the rivers or ponds it was expected to get water filtered from the neighboring surface supply. It was found, however, that the water from the galleries differed very much in chemical analysis, temperature and appearance from the surface waters, and before pumping stood at a higher level.

From all this it was concluded that the water did not come from the neighboring pond or stream but from the land side.* Two instances are given in Table No. 3 of analyses of surface waters and of the filtered or ground waters beside them.

* Where water from the land side is mentioned in this report, it refers only to water derived from rainfall soaking directly into the ground, and not to that which frequently enters a filter gallery or well from the land side, having come by a circuitous course from the adjoining pond or stream.

TABLE No. 3.

Analyses of Samples of Water taken from a pond and from a filter gallery beside it, also from a river and from driven wells near its banks.

[Figures express parts per 100,000.]

	Pond.	Filter Gallery.	River.	Driven Wells.
Date of taking sample, .	July 11,'87.	July 11,'87.	July 11,'87.	July 11,'87.
Date of examination, .	" 13, "	" 13, "	" 11, "	" 11, "
Sediment, . . .	Light brown flocky.	None.	None.	None.
Turbidity, . . .	Decided.	None.	Slight.	None.
Color,*	0.4	None.	1.0	None.
Odor, cold, . . .	Peculiar and offensive.	None.	Faint.	None.
Odor, hot, . . .	Strongly offensive and persistent.	None.	Very faint.	None.
Total residue, . . .	12.74	11.70	5.95	6.10
Loss of residue on ignition,	2.17	1.95	1.75	0.75
Fixed residue, . . .	10.57	9.75	4.20	5.35
Odor and characteristic on ignition, . .	Strongly peaty and somewhat disagreeable.	Disagreeably irritating and acid.	Strongly peaty.	Peculiar and acid.
Free ammonia, . .	0.0042	0.0012	0.0069	0.0000
Albuminoid ammonia, .	0.0803	0.0022	0.0432	0.0010
Chlorine, ...	2.94	2.29	0.58	0.81
Nitrogen as nitrates, .	0.003	0.034	None.	0.039
Nitrites, ...	None.	None.	None.	None.
Hardness, . . .	5.57	5.57	–	3.38
Temp. of water at source,	About 77°	About 52°	76°	51°

From an examination of this table it will be seen that there is a very decided difference in the character of the two classes of waters in nearly every respect except in residue and chlorine.

* Colors are designated by a scale of figures increasing with the increase of color: 1.0 represents a distinct yellowish brown when seen in a depth of five or six inches; 2.0 represents a decided yellowish brown. Odor is obtained by agitating the water in a closed bottle, about half full, and then smelling the air.

Sediment, turbidity, color and odor (cold and hot) do not appear in the water taken from the ground, the ammonias are very much diminished, and the nitrates are increased. The temperature of the ground water was also much less at the time of year when these samples were taken.

There are several reasons why it seems probable that water drawn from filter galleries, or by other means from the ground in the vicinity of bodies of surface water, comes to a large extent from the latter source; and it was thought that if this could be shown to be the case, and it could be shown at the same time that the filtered water lost the general characteristics of surface waters and assumed those of ground water derived from rainfall soaking into the ground, the knowledge would be of much practical value to those locating or enlarging a ground-water supply.

To settle the question, if possible, a special case was chosen for thorough investigation where the supply for a town was pumped from a filter gallery, distant about 130 feet from the shore of a pond.

The amount of water pumped from this gallery during the year equals a daily average of about 900,000 gallons. The pumps are operated during each week day for about ten hours, no pumping being done on Sunday.

The level of the water in the filter gallery remains permanently below the surface of the pond, lowering when the pumps are in operation and rising when they are stopped. These fluctuations vary in extent at different times of the year. In December, 1887, the water rose to within about one foot of the level of the pond on Monday mornings, when the pumping had been discontinued for thirty-eight hours, while other mornings it was six inches lower. In the evening it was about four feet below the pond.

The mean of seven analyses, made monthly from June to December, 1887, of the water of this pond and of the filter gallery beside it, are given in Table No. 4.

In the last column of the table is given a mean of corresponding analyses of water from an open distributing reservoir, into which water is pumped from the filter gallery. Reference will be made to this in a subsequent portion of this report.

TABLE NO. 4.

Mean of Seven Analyses made monthly from June to December, 1887, of the water of a pond, a filter gallery beside it, and an open distributing reservoir into which water is pumped from the filter gallery.

[Figures express parts per 100,000.]

	Pond.	Filter Gallery.	Open Distributing Reservoir.
Sediment, ...	Some.	None.	A little.
Turbidity, ...	Considerable.	None.	Some.
Color,*	0.4	0.0	0.0
Odor, cold, ...	Considerable.	None.	Some.
Odor, hot, ...	Considerable.	None.	Some.
Total residue, . . .	13.79	12.06	11.81
Loss of residue on ignition,	2.19	1.54	1.57
Fixed residue, . . .	11.60	10.52	10.24
Free ammonia, . . .	0.0149	0.0014	0.0032
Albuminoid ammonia, .	0.0480	0.0028	0.0105
Chlorine, ...	3.74	2.40	2.30
Nitrogen as nitrates and nitrites, ...	0.022	0.031	0.017
Nitrites, ...	Present twice.	None.	Present once.

This particular source of water supply was chosen in preference to any other because the pond was artificially salted by the drainage from manufacturing establishments on its feeders; so much so that it contained about ten times as much chlorine (one of the components of common salt) as most ponds at the same distance from the sea and not affected by drainage.

The value of an abnormal amount of salt in a surface water for determining the source from which water comes to a filter gallery lies in the fact that it is a stable chemical compound, and is not removed when the water containing it in solution is filtered through the ground.

In proof of the latter part of this statement numerous instances may be cited where analyses of filtered and unfiltered water show

* For scale of color see foot note, p. 79.

the same amount of chlorides. The most conclusive proof, however, is furnished by the careful and extended experiments made at the Massachusetts Institute of Technology by the late Prof. Wm. Ripley Nichols and described by him in a paper * presented to the Boston Society of Civil Engineers, April 16, 1884.

It is, of course, possible for water passing through ground containing salts to dissolve them and so increase their proportionate amount in the water; and in the case of filtration from a pond or stream into a filter gallery the latter may contain more or less salt than the former, owing to the admixture of water coming from the land side.

By reference to Table No. 4 it will be observed that the water of the filter gallery contains 2.4 parts of chlorine per 100,000, or about six times as much as is usually found in water at this distance from the sea. This large quantity may be accounted for in two ways: either by the filtration of water from the pond, or by some abnormal condition of the soil which makes the water from the land side rich in chlorides. To determine whether or not the water from the land side presented this unusual feature, samples of water were collected from an unpolluted brook and pond in the vicinity, and from several pits dug deep enough to collect water coming to the filter gallery from the land side. In the samples of the water from the pond, brook, and three of the pits in which the water stood at a *higher* level than in the pond, the amount of chlorine varied from 0.25 to 0.45 in 100,000, averaging 0.37, or less than one-sixth of the amount in the filter gallery. Just what the figures that have been given mean may be more easily understood by showing the results in a different form.

The average amount of water pumped daily from the filter gallery may be stated in round numbers as 900,000 gallons or 7,500,000 pounds.

The chlorine in the water is found to be 2.4 parts per 100,000, equivalent to 180 pounds of chlorine in the daily pumpage.

If it is assumed, as is probably the case, that all the chlorine in the water is combined with sodium in the form of common salt, it can be shown from the relation which these two components always bear to each other that the total amount of salt pumped per day is 297 pounds. An equivalent amount of water derived from the land side would contain only 46 pounds of salt, while the same amount of water derived wholly from the pond would contain 462 pounds.

These figures not only show that the water in the filter gallery is a mixture of the waters from the pond and the land side, but

* On the Filtration of Certain Saline Solutions through Sand: Journal of the Association of Engineering Societies, vol. iii., p. 139, 1884.

they permit a fairly good estimate to be made of the proportion which must come from each source to produce the degree of saltness equivalent to that found in the water from the gallery.

Such an estimate shows 60 per cent. of the water to have come from the pond and 40 per cent. from the land side, during the seven months under consideration.

Other investigations were made to determine the source supplying water to this gallery, and they may be mentioned in a subsequent report when the investigations of the whole year are completed. They were generally corroborative of the results here given.

Before leaving the subject of the source of this water supply it may be well to state that it is improbable that much of the water derived from this pond comes through the comparatively narrow strip of ground separating the pond from the gallery; in fact, the statement may be made in a general way that in the bed of a stream or pond the spaces between the grains of sand and gravel usually become choked up with silt and vegetable matter to such an extent that little water will pass through any given square foot of surface; and it is only where a large area of bed overlies or adjoins the porous stratum that it is safe to expect that a large supply can be obtained by filtration.

When the water is once in a coarse gravel stratum of considerable extent it may find its way readily to a filter gallery even from a long distance. That some of the water came from a long distance to the gallery in the case specially investigated was proved by test pits dug near the shore across an arm of the pond and 1,000 feet from the gallery.

The water surface in these pits stood several inches below that in the pond, fluctuated with the change of level in the filter gallery, and the water from them contained more than the normal amount of chlorine found in the ground water in this vicinity, showing that some of the pond water passed through these pits on its way to the gallery.

Coarse gravel will hold in its interstices about 30 per cent. of its volume of water, and where the gravel beds are extensive the large body of water contained in them has to move slowly towards the filter gallery to furnish the amount pumped, so that some of the water may be weeks or even months in its passage through the ground.

Upon examining the relative analyses of water from the pond and filter gallery, as given in Table No. 4 on page 81 it will be observed that in most features the difference between the two cannot be accounted for by the mixture of water from the pond and land side in the proportion before stated. Sediment, turbidity,

color and odor (cold and hot) which are very noticeable in the pond water, are absent in the water from the filter gallery. The residues and chlorine do not show a greater difference than can be accounted for by the mixture of the waters.

The change in the ammonias is the most noticeable feature, the gallery water containing but one-eleventh as much free ammonia and one-seventeenth as much albuminoid ammonia as that from the pond. The greater amount of nitrogen as nitrates and nitrites (nearly all nitrates) in the gallery water, might be accounted for by the mixture of the waters, but it is more probable that the increase is due to the oxidation and consequent purification of the decomposing nitrogenous matters indicated in the pond water by the presence of the ammonias.

The water of the pond is shown by the analyses to be entirely unfit for drinking, while water from the gallery analyzes well in many respects,but is to be viewed with some suspicion on account of its source.

In addition to the chemical analyses of these waters, other examinations were made to determine whether bacteria and the grosser forms of microscopic life (algæ, etc.) found in the pond water were removed by its filtration through the ground to the gallery.

The number of bacteria found per cubic centimeter in the pond water Oct. 12, 1887, was 70; in the water from the gallery, 13. On the 12th of December, 1887, the numbers found were respectively 65 and 1. The mean of these results shows that the gallery water contains but one-tenth as many as that from the pond. The species were not determined, and it is not known whether the bacteria found in the gallery were developed there or whether they came through the ground. In many other instances in this State, where comparisons have been made of the number of bacteria in surface waters and in the filter galleries or wells beside them, much greater differences have been found than in the cases above given; an extreme instance showing a ratio of 16,500 to 2.

The bacteria found in all of these cases may have been and probably were harmless, but since the best known of the pathogenic bacteria are no smaller, it seems fair to assume that the means which will remove one will remove the other.

That filtration through even a moderately thin layer will, under proper conditions, remove a very large percentage of the bacteria from water, has been very definitely shown by the experiments of Dr. Percy F. Frankland* by practical experience in the filtration

* Water-purification, its Biological and Chemical Basis, by Percy F. Frankland, Ph.D., etc.; Proceedings of the Institution of Civil Engineers, vol lxxxv., London, 1886.

of the water supplies of London and Berlin, and by recent experiments at the Lawrence Experimental Station, described in the report of the Board which this accompanies. In fact, the efficiency of the Berlin filter beds is now determined by the percentage of the bacteria which they will remove from the water.

The examination of the waters of the pond under consideration, for microscopic growths other than bacteria, showed the presence in abundance of several species of algæ, some of which were gelatinous forms which readily decompose and produce disagreeable tastes and odors in the waters; other growths were present in small numbers. The water of the filter gallery did not contain any of the species of organisms found in the pond, though it did contain a few other species, — one in some abundance.

These results are in accordance with those obtained from other water supplies somewhat similarly situated.

In the warmest weather in summer the temperature of the water of the pond was as high as 80° Fahrenheit, while that of the filter gallery was about 52°.

As a general result of these special examinations, corroborated in many respects by similar results found at other water supplies in the State, the following practical conclusions may be drawn: —

That it is practicable in many instances to obtain a supply of water from a bed of porous gravel adjoining an unfailing pond or stream, without reference to the amount of water that may be obtained from the land side.

That where the soil does not contain soluble matters to injuriously affect the water, it will, when so obtained, be much purer by chemical and biological standards, will be much cooler in summer, and in all sanitary and commercial features will be much better than water taken directly from the pond or stream.

That since it is impracticable in many cases to get an entirely satisfactory supply of water, it is preferable to obtain a ground-water supply by filtration from a surface source that is somewhat objectionable, rather than take surface water directly from a source that is some degrees less objectionable.

There are other conclusions which ought not to be drawn to which it is equally well to call attention.

It should not be inferred that the results above indicated will be obtained where only a thin layer of sand or gravel intervenes between the surface source and the filter gallery, and the filtration is continuous, since examinations, in several instances, of water filtered under such circumstances have shown it to be worse than that which had not been filtered: nor should it be inferred that it

is safe to take a supply by filtration from a seriously polluted body of surface water, since, while the chemical analyses show by far the larger portion of the decomposable organic matter indicated by the ammonias to have been removed by filtration, yet the small amount remaining may be of a harmful nature, and there is no definite assurance that the purifying powers of the soil may not at times be overtaxed.

It may properly be urged as an objection to seeking a supply of ground water that the quantity to be obtained cannot be told with the same certainty as that from a visible supply. The quality of the water, however, makes it desirable to secure such a source when practicable; and while the exact amount of water cannot be ascertained in advance of the actual construction and test of the well or filter gallery, a competent engineer, experienced in these matters, can form a judgment upon which much reliance may be placed.

In Table No. 4, on page 81, in addition to the analyses of the waters of the pond and the filter gallery, already discussed, the third column gives the mean analysis of the water in the open distributing reservoir.

When the pumps are in operation, the surplus water goes to this reservoir, and nights and Sundays when the pumps are stopped it furnishes the water used. Complaint is made in summer by those using the water that it tastes badly when it comes directly from the reservoir, while that coming directly from the filter gallery does not.

The chemical analyses show that in nearly all other respects the water has seriously deteriorated in quality by storage. Sediment, turbidity and odor make their appearance in the reservoir water. Free and albuminoid ammonia, indicating the presence of decomposing or decomposable nitrogenous organic matter, have greatly increased, while the nitrogen in the form of nitrates has decreased, apparently by the passage of a portion of the nitrogen from the inorganic to the organic condition.

A cause for this and a practical remedy appear to have been found by Mr. G. H. Parker, the biologist of the Board, charged with the examination of water for organisms other than bacteria, and are contained in his accompanying report.

The remedy which he proposes (the entire exclusion of light to stop the growth of vegetation) has been applied in the case of the iron storage tank of the Brookline high service, and the serious trouble from bad taste, which previously existed, has entirely

ceased; moreover, the chemical purity of the water in the tank is as great as at the source.

A result corresponding to the last statement has been found under similar circumstances at several other places in the State similarly situated.

The marked deterioration, as determined by chemical analyses, of ground water stored in large open reservoirs, is a feature in all cases that have been examined. The amount of deterioration is somewhat variable.

Table No. 5 has been prepared to show the change due to storage that has taken place in six water systems during six months. The general result is the same as in the special case before given. The increase in the ammonias is even more marked.

Table No. 5.

Mean of Analyses made monthly from June to November, 1887, of the waters of six filter galleries or wells and of the corresponding open distributing reservoirs into which the water is pumped from the filter galleries.

[Figures express parts per 100,000.]

	Filter Galleries or Wells.	Open Distributing Reservoirs.
Sediment,	None.	A little.
Turbidity,	None.	Some.
Color,	None.	None.
Odor, cold,	None.	Some.
Odor, hot,	None.	Some.
Total residue,	8.86	8.82
Loss of residue on ignition,	1.19	1.39
Fixed residue,	7.67	7.43
Free ammonia,	0.0004	0.0011
Albuminoid ammonia,	0.0017	0.0117
Chlorine,	1.13	1.09
Nitrogen as nitrates,	0.088	0.064

In a majority of cases water from such reservoirs has, at times, tasted badly. In but few cases has trouble of this kind been reported from water stored in iron tanks; but these few cases, and particularly the one already mentioned, make it desirable to exclude the light from any to be built in the future, or from any that give trouble at the present time. Where water from a pond or other surface source is pumped and stored in an open distributing reservoir no marked change in the analysis takes place.

Respectfully submitted,

F. P. STEARNS,
Chief Engineer.

Office of the State Board of Health,
13 Beacon Street, Boston, Jan. 9, 1888.

APPENDIX A.

REPORT OF THE BIOLOGIST.

CAMBRIDGE, Jan. 4, 1888.

To H. P. WALCOTT, M. D., *Chairman State Board of Health.*

Sir: — The following report contains a brief preliminary account of the organisms, excepting the bacteria, found in certain potable ground waters. The influence of the organisms on the water and a remedy for their deleterious effects is discussed at some length. A fuller consideration of this topic and an account of the organisms found in surface waters will be deferred till a later report. As there is considerable variation in the plans of the six water systems examined they will be treated separately.

Brookline. — The source of supply for the water of the town of Brookline is a filter gallery lying parallel with and near to the Charles River. The gallery is completely closed and the water which is in perfect darkness is pumped from this gallery to two storage reservoirs, one an iron tank for the high service of the town, and another the open reservoir for its general service. The high service tank and open reservoir were the places where the water first met the light. From these two reservoirs the water is conducted by distributing mains to the town.

The quality of the water delivered in the town was at times far from satisfactory. A strong taste and odor were often present in it, and these were the more marked when it was contrasted with the water at the pumping station. This latter was clear and completely free from disagreeable taste or smell.

An examination of the microscopic contents of the water in the open reservoir was made July 14. The water was found to contain five species of green algæ, — Pediastrum, Eudorina, Volvox, Staurastrum and Asterionella, the last two of which were abundantly represented. In addition to these there were a few filaments of a blue-green alga, Oscillaria, and the decomposed remains of an entomostracan (water flea). As the green algæ were the only organisms abundantly present in the water and as there was no source of contamination, other than the contained organisms, it

was suggested that the disagreeable taste and smell was in the main due to the minute green plants.

The question then naturally proposed itself, was there any means of ridding the water of these plants? It has been known for some time that the life of all green plants is dependent upon certain materials and surroundings. In order that a green plant should continue to live and grow it must have, in addition to a few less constant materials, some nitrogenous compound, water, carbon dioxide and oxygen. These in themselves, however, are not sufficient to nourish the plant; they can be utilized only in the presence of sunlight. So exacting is this latter requirement that any green plant destitute of food stored in its own tissues, if placed in perfect darkness, dies at once.

With this in mind as a working theory, it was suggested that the high service tank at Brookline should be completely covered and all light excluded. The tank was emptied, cleaned and a double roof with eaves was placed on it. This was impervious to the light and from time to time was examined to ascertain that no cracks had opened. Water was introduced and on October 7 a second microscopic examination was made.

At this examination samples were taken at the pumping station, high service tank and open reservoir. The method of taking the samples is as follows: In cases where a faucet is available a stout cotton cloth is tied over the nozzle and about seven gallons of water are strained through it. This amount of water is sufficient for an ordinary examination and can be passed through the cloth in as short a time as fifteen minutes, without producing pressure enough to drive the organisms through the meshes.

In cases such as the open reservoir, where no faucet was available, a piece of cloth was stretched on a net frame and carried through the water. Such sample cloths should be placed in clean bottles previously rinsed with water from the same source as that for the sample. The contents of the cloth should be examined as soon after collection as possible, certainly within thirty-six hours. This limit is partially dependent upon temperature; in cold weather the cloths can be kept longer than at warmer periods. If the cloths cannot be examined at once they should be dried shortly after the collection is made, and in this state they can be preserved for months. When it is desirable to examine these dried cloths they can be moistened with distilled water. In the case of the Brookline water all the samples were examined while fresh.

The sample cloth from the pumping station showed no green algæ whatever. As the water in this portion of the system is in perfect darkness, the absence of green algæ agrees well with

the theory. Several filaments of Leptothrix, insignificant in amount, were all that was found. The water was clear and devoid of disagreeable smell or taste.

The sample cloth from the open reservoir showed as previously an abundant supply of green algæ, a few representatives of the genera Pandorina and Staurastrum, an abundance of two species of diatoms and of one species of Anomopedium, with Raphidium and Volvox represented in still greater abundance. The water was slightly cloudy and had a very strong taste and decidedly fishy smell.

The sample cloth from the high service tank, now completely darkened, contained only one specimen of green alga, Closterium. This may possibly have been on the nozzle of the faucet, although this was washed before the cloth was put on. In addition to the alga there were several filaments of Hypheothrix which were probably growing in the tank. These, however, like the Leptothrix of the sample from the pumping station were insignificant in amount. The water from the high service tank was now free from odor and taste, and for all practical purposes as good as that pumped at the filter gallery.

From these observations it seems fair to conclude that since the unpleasant taste and smell in the water disappear with the disappearance of the green algæ, these latter are the cause of the taste and smell, and that any means by which the light is excluded from the storage reservoirs, filter basins, etc., will be sufficient to prevent the growth of green algæ.

What has been said applies only to the green algæ, and it is very natural for one to ask are there not other forms of vegetable or animal life which may adapt themselves to darkened chambers and in time become sources of contamination for the water. The possibility of this has already been suggested by the fact that in the closed tank and filter gallery two plants, Hypheothrix and Leptothrix, have been noticed. Could not these multiply to such an extent that in time they would become as noxious as the green algæ?

Before answering this question, we must glance for a moment at the relation which organisms sustain to their supply of food. All organisms depending upon the way in which they acquire their nutriment can be divided into two groups. The first group includes those which manufacture their food from certain simple chemical compounds. In order to carry on this work they must have some source of energy; this they find in sunlight. This group includes all green plants. The members of the second group, the animals and such plants as contain no [green coloring

matter, do not manufacture their own food, but nourish themselves by feeding directly or indirectly on organisms of the first group. For instance, man is a member of the second group; his food comes from two sources, other animals and green plants. At first sight the former might seem a source of food independent of green plants, but a moment's reflection will show that the animals used for nourishment are in their turn dependent for food either directly on green plants or on some other animal which in its turn is dependent on vegetation. Thus ultimately all animal food is derived from green plants. As sunlight is essential to members of the first group, so are representatives of this group or some product of their decomposition essential to the life of members in the second group. It is conceivable, then, that a member of the second group, an animal for instance, may live in perfect darkness so long as it is supplied with nourishment derived directly or indirectly from green plants, but as the exclusion of light destroys the green plant, so the exclusion of the green plant or its products of decomposition will destroy the animal.

Hypheothrix and Leptothrix, the two plants found in small numbers in the darkened tank and filter gallery, are members of the second group. They depend for their food upon partially decomposed products of members of the first group. Water which has percolated for a considerable distance through soil usually contains a low percentage of these products, and the presence of Hypheothrix and Leptothrix indicates that in this case that small amount is utilized as food. It will also be noticed that since the source of the Brookline water is free from any green growth the amount of nutriment contained in the water must be relatively small, consequently the Hypheothrix and Leptothrix, being dependent upon this food for their growth, will probably never reach harmful proportions. This conclusion is further supported by the fact that in the Watertown system, to be described later, the Hypheothrix is found, and, although this system has been in operation for some years and the opportunities for growth are quite as favorable as in the high service tank at Brookline, the plant remains as inconspicuous at Watertown as at Brookline.

How far the conclusions obtained from the examination of the Brookline system are supported by other evidence will be seen from the following description of the five remaining systems.

Waltham (Nov. 23, 1887).— In the system at Waltham, the water is pumped from an open filter basin on the Charles River to an open reservoir, and is then distributed to the town. If we neglect the high service tank of the system at Brookline, this system is essentially like that of the last named town, except that

the filter gallery is replaced by an open basin. With this difference we should expect to find green algæ not only in the reservoir but also in the filter basin. An examination of the water in the filter basin shows this to be true, for in addition to a large growth of Spirogyra, a partially attached green alga, seven species are found floating abundantly in the water.

Woburn (Oct. 12, 1887).— In the system at Woburn, the water is pumped from a filter basin not completely darkened into a main which distributes it to the town, and allows the surplus to flow back into a small reservoir. Our theory would predict a slight growth in the filter basin and an increased growth in the open reservoir. On examination the water from the filter basin contained a single specimen each of four species of green algæ and some filaments of Hypheothrix. In the reservoir two species from the gallery were found in abundance, and two others were also present. One, a Conferva, grew in large matted masses which, when dried, resembled the material of wasps' nests.

Newton (November, 1887).—The filter basin in this system is a long open canal running parallel to the Charles River. From this basin the water is pumped into a distributing main, and the surplus is stored in an open reservoir. From the exposed nature of the filter basin and reservoir we should expect in both an active growth of green algæ. Examinations of the water show that, besides the growth of Spirogyra, which occurs along the bottom of the filter basin, the water contains suspended in it six species of green algæ. Three of these were abundantly represented. The water in the reservoir contains nine species of green algæ, four of which are abundant. This increase in variety, and number of the species found in the reservoir over those in the filter basin, is perfectly consistent with a continued exposure of the water to sunlight.

Revere (Dec. 12, 1887).—At Revere the water from a series of driven wells is discharged into a chamber lighted by windows, and from this collecting chamber it is pumped into distributing mains. The overflow is collected in an open reservoir. Under these conditions a slight growth in the collecting chamber and an increased growth in the open reservoir might be expected. An examination of the water gives the following results: The water in the collecting chamber contains a few each of three species of green algæ; in the reservoir four species of green algæ are present; two of these are of the same species as those in the chamber. Of the four two are abundant and one is very abundant.

Watertown (Nov. 6, 1887).—The filter basin in this system is in part open so that one end receives diffused daylight. From

this the water is pumped into the distributing main and the overflow is collected in a tank. This tank, although covered with a roof, has an air space above it into which a number of windows open. The filter basin receives fully as much light as the same structure in the Woburn system, and as this latter contained a few green algæ one would expect naturally a similar growth at Watertown. The tank, of course, receives much less light than an open reservoir, but there appears to be sufficient light to warrant the expectation of a few green algæ. An examination of the water in both the filter basin and tank shows only a few filaments of Hypheothrix. This at first sight may seem exceptional. By way of explanation, however, it may be said that in situations such as filter basins the presence of light only renders possible the life of green algæ but does not necessitate their growth. The Watertown system then may be one in which green algæ have not as yet made their way, but if once planted they might multiply there as elsewhere. It is noticeable, however, that owing to the small amount of light entering the filter basin and tank the growth of green algæ would probably never become conspicuous, not to say harmfully abundant. The water from this system as well as that from Revere has never been noticed to have any disagreeable taste or smell.

With this, the account of the examination of the ground waters is concluded. Excepting the conditions at Watertown, which have already been discussed, the four open reservoirs and four open filter basins examined all contained green algæ. When the algæ were abundant a disagreeable taste and odor characterized the water. The tank and filter gallery at Brookline, both completely darkened, contained no green algæ. In these two situations the water had no disagreeable taste or smell. From these facts it would appear that the green algæ are, in the main, the cause of the bad taste and smell in the water and that these plants are dependent for their existence on sunlight. It is therefore concluded that the complete exclusion of sunlight from storage reservoirs, filter basins, etc., is an efficient practical remedy for the deleterious effects of these organisms.

Respectfully submitted,

G. H. PARKER.

Commonwealth of Massachusetts.

[Chap. 274.]

An Act to protect the purity of inland waters.

Be it enacted, etc., as follows:

Section 1. The state board of health shall have the general oversight and care of all inland waters and shall be furnished with maps, plans and documents suitable for this purpose, and records of all its doings in relation thereto shall be kept. It may employ such engineers and clerks and other assistants as it may deem necessary: *provided*, that no contracts or other acts which involve the payment of money from the treasury of the Commonwealth shall be made or done without an appropriation expressly made therefor by the general court. It shall annually on or before the tenth day of January report to the general court its doings in the preceding year, and at the same time submit estimates of the sums required to meet the expenses of said board in relation to the care and oversight of inland waters for the ensuing year; and it shall also recommend legislation and suitable plans for such systems of main sewers as it may deem necessary for the preservation of the public health and for the purification and prevention of pollution of the ponds, streams and inland waters of the Commonwealth.

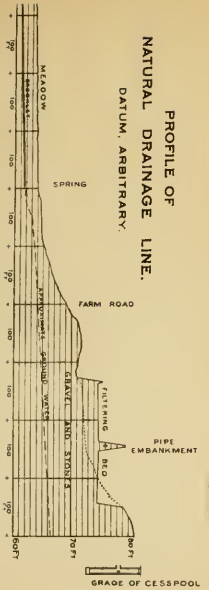
Sect. 2. Said board shall from time to time as it may deem expedient, cause examinations of the said waters to be made for the purpose of ascertaining whether the same are adapted for use as sources of domestic water supplies or are in a condition likely to impair the interests of the public or persons lawfully using the same, or imperil the public health. It shall recommend measures for prevention of the pollution of such waters and for removal of substances and causes of every kind which may be liable to cause pollution thereof, in order to protect and develop the rights and property of the Commonwealth therein and to protect the public health. It shall have authority to conduct experiments to determine the best practicable methods of purification of drainage or disposal of refuse arising from manufacturing and other industrial establishments. For the purposes aforesaid it may employ such expert assistance as may be necessary.

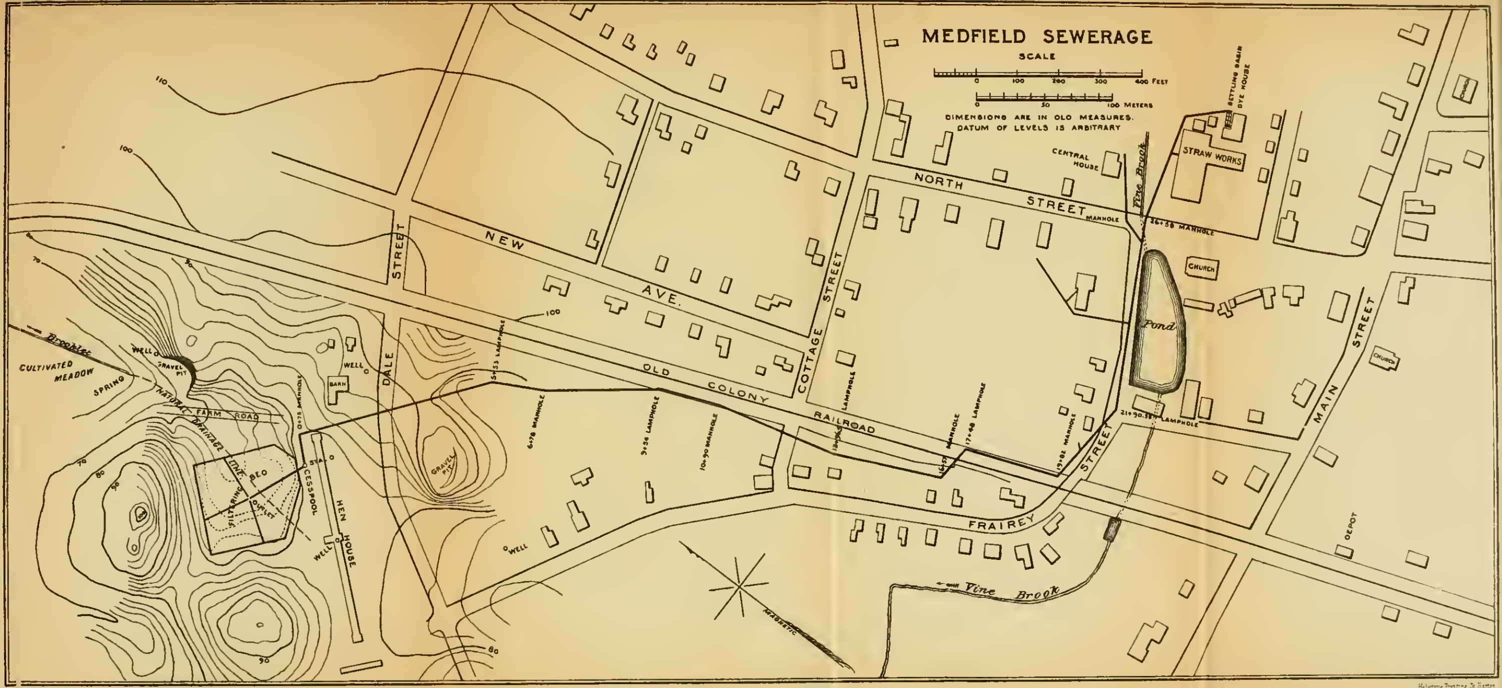
SECT. 3. It shall from time to time consult with and advise the authorities of cities and towns, or with corporations, firms or individuals either already having or intending to introduce systems of water supply or sewerage, as to the most appropriate source of supply, the best practicable method of assuring the purity thereof or of disposing of their sewage, having regard to the present and prospective needs and interests of other cities, towns, corporations, firms or individuals which may be affected thereby. It shall also from time to time consult with and advise persons or corporations engaged or intending to engage in any manufacturing or other business, drainage or refuse from which may tend to cause the pollution of any inland water, as to the best practicable method of preventing such pollution by the interception, disposal or purification of such drainage or refuse: *provided*, that no person shall be compelled to bear the expense of such consultation or advice, or of experiments made for the purposes of this act. All such authorities, corporations, firms and individuals are hereby required to give notice to said board of their intentions in the premises, and to submit for its advice outlines of their proposed plans or schemes in relation to water supply and disposal of drainage or refuse. Said board shall bring to the notice of the attorney-general all instances which may come to its knowledge of omission to comply with existing laws respecting the pollution of water supplies and inland waters and shall annually report to the legislature any specific cases not covered by the provisions of existing laws, which in its opinion call for further legislation. —[*Approved June 9, 1886.*

Acting under the provisions of this act, the State Board of Health is ready to consult with and advise the authorities of cities and towns and others, and to receive outlines of proposed plans from them, as provided in section 3 of chapter 274, Acts of 1886.

SEWAGE DISPOSAL AT MEDFIELD, MASS.

By FRED. BROOKS, Civil Engineer.





Heliotype Printing Co. Boston

SEWAGE DISPOSAL AT MEDFIELD, MASS.

By FRED. BROOKS, Civil Engineer.

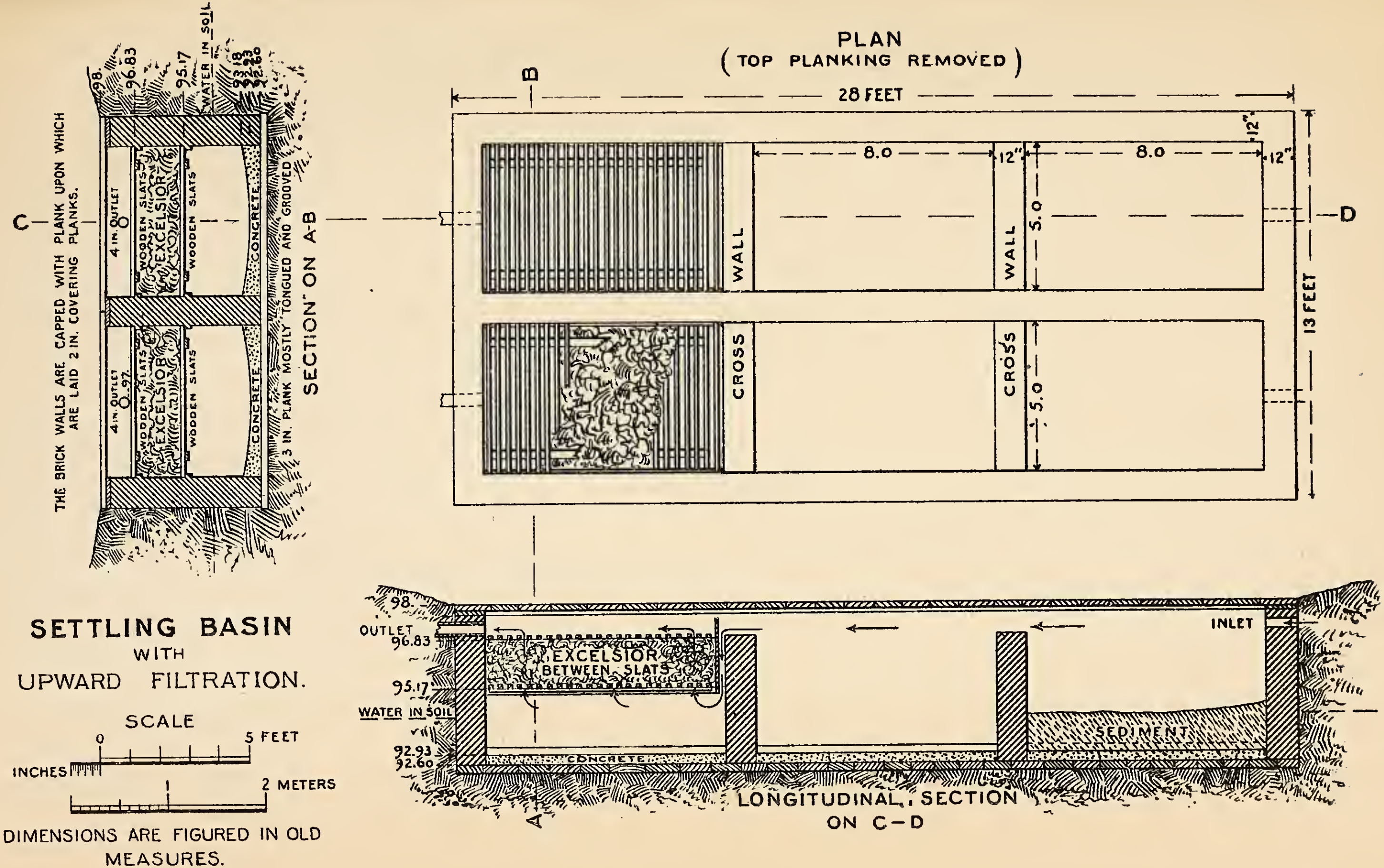
Medfield is an old town on the Charles River, seventeen miles from Boston. Its population in 1885 was 1,594; valuation, $1,110,858; receipts and expenditures, about $18,000 each; so that, relatively to the size of the place, the sewerage here described, which cost but a few thousand dollars, is comparable with the costly sewerage works of great cities. The business of Medfield is mostly agricultural, the principal exception being the Excelsior Straw Works in the middle of the town, employing in the busy season six or seven hundred operatives, but during about five months in the summer and fall, not more than half as many. The general plan folded herewith (Plate I) will enable the character of the work of sewerage to be understood with the aid of a brief description.

The straw works drainage, nearly half of which comes from the vats in which straw is dyed, used to run into Vine Brook, which flows past the works and is dammed up in a small pond just below, whose level is frequently raised and lowered for mechanical purposes. This produced an offensive smell around the pond, and blackened and polluted the water so that some residents below, on both sides of the brook immediately west of the railroad track, who had used its water for domestic supply, were obliged to abandon it, and made several complaints. In 1886 a pipe sewer was built chiefly for the purpose of keeping the sewage from the straw works out of Vine Brook, and disposing of it so as to avoid the nuisance. The sewer has been entered also by the Central House (having accommodations for about forty boarders), which formerly drained into the brook, and by three private dwelling-houses which did not drain into the brook. As a result the channel of the brook has already been washed so that it is inoffensive to sight and smell. A

favorable place was found a little out of the village for the discharge of the sewage, and its purification by intermittent downward filtration.

The work was projected by Eliot C. Clarke, C. E., and the details of its execution were put under the charge of the writer. The plans were presented to the State Board of Health in August, 1886, and were approved by the Board.

Much ground dye-wood is used at the straw works, and if this in its water-logged condition were admitted to the sewer it was not to be supposed that the sewer would be self-cleansing with the gradient available. It falls at the rate of 4 per 1,000 for nearly a quarter of a mile. Accordingly to exclude the spent dye-wood from the sewer there was built adjacent to the dye-house a settling basin with a filter, whose construction may be understood by the aid of the accompanying drawing (Plate II). It is made in two parts, side by side, exactly alike, in order that one-half may be in use, if necessary, while the other is being cleaned out. The discharge from the vats can be turned by a wooden gate in the trough which brings it from the dye-house into either side of the settling basin separately. Entering by the four-inch openings the liquid flows generally in both sides with a total width of ten feet and a depth of four feet less the thickness of the deposit of sediment. The velocity of flow is thus checked, and the ground dye-wood has a chance to settle. To get into the second pair of compartments it has to pass over the brick dividing wall, whose elevation is the same as the bottom of the inlet pipe. Here is another opportunity for settlement to take place, but apparently very little collects in the second compartments until the first are pretty well filled. In the third compartments by a tight board partition the liquid is obliged to pass downward, and escape by upward filtration through a mass of excelsior held between two sets of wooden slats, as exhibited by the drawing; the upward flow being preferred, as a precaution against choking the filter. The filter was in use nearly a year before the excelsior was changed; it worked very satisfactorily, but the excelsior had by that time become so rotted that probably it would soon after have gone to pieces and escaped through the sewer. A new supply was accordingly substituted. The sediment needs to be shoveled out and



SETTLING BASIN
WITH
UPWARD FILTRATION.

DIMENSIONS ARE FIGURED IN OLD MEASURES.

carted off once or twice a year; it has a similar appearance to saw-dust, except for its black color.

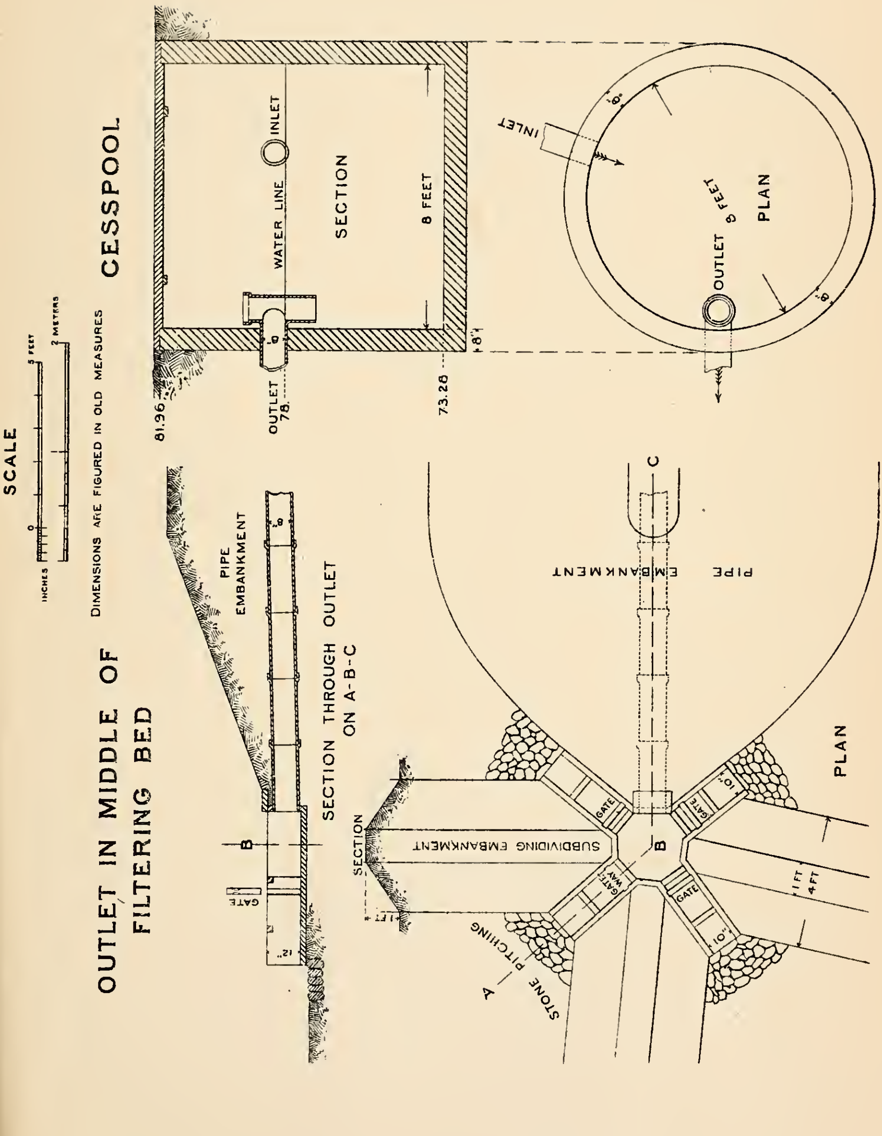
From the settling basin the sewer of Akron vitrified clay pipe runs four inches in diameter to where other drainage of the straw works enters from the water-closets, sinks, bleachery, etc. There it enlarges to six inches, which is the diameter as far as the North Street man-hole. The portion above mentioned, and also the branches to houses, were built at private expense. From the North Street man-hole the main sewer was built by the town of Medfield as a common sewer, intended to admit sewage from shops and houses, but to exclude rain-water entirely. It is eight inches in diameter, and has capped branch pieces set at several points to admit of ready extension of sewerage through the thickly settled parts of the village, if required in the future. The sewer passes under Vine Brook at North Street, and for some distance both above and below that point it is below the level of the water in the soil. Three lengths of pipe under the brook (thirty-six feet in all) are of iron, with lead joints, and are probably tight. The rest of the sewer is laid with Akron pipe, jointed with cement mortar; and although it was intended to be water-tight, it in fact admits water from the soil, both above and below the brook crossing. The quantity thus leaking in was approximately estimated, before sewage was admitted, by pumping out all that came to the North Street man-hole and determining the rate of pumping by observing how long it took to fill a pail; also by measuring at the same time the depth of the water flowing in the sewer at the man-hole by the railroad bridge. It was estimated a year later by observing the minimum flow, as on holidays, when little sewage is running. The quantity appears to be about 2,000 cubic feet per 24 hours, and does not appear to have increased or diminished materially. This leakage is likely to continue until a portion of the Akron pipe is replaced by iron pipe.

The sewer does not fall at so rapid a rate as Vine Brook, and after passing close beside the pond the rest of the sewer is laid in dry gravel. The line of the sewer diverges more and more from the brook, and as it approaches Dale Street it passes out of the watershed of Vine Brook.

Near the lower end of the sewer the sewage passes through

a cesspool arranged as shown on the accompanying drawing (Plate III.), so that the outflow takes place from beneath the surface of the sewage standing in the cesspool. The effect is that objects which either float or sink are held back until they are sufficiently changed by chemical or other action to flow uniformly with the rest of the liquid, and are prevented from being thrown out upon the ground at the outlet, where lumps of fœcal matter, orange peel, and the like might be offensive or ill-adapted for percolating through the ground. Very little sediment collects in the cesspool, — only about a foot in depth in the course of a year; when it fills up, the sediment will have to be taken out.

It takes about half an hour for sewage to pass from the dye-house through the sewer, which is nearly 3,200 feet in extreme length, to the outlet, where it flows out upon the surface of the ground. This disposal of it is the principal subject of interest about the work. The filtering bed upon which the sewage is discharged consists of one acre of ground graded nearly level. It was intended to be conical, sloping at the rate of five per thousand away from the centre, where the outlet of the sewer is; but owing to slight imperfections in the work, unequal settlement, etc., it is a little irregular, — generally flatter. Material was excavated from the higher exterior portion of the site selected and filled in upon the lower portion, so as to balance the cutting and filling, as may be seen by the accompanying profile of the natural drainage line, and by the general plan, which exhibits by dotted lines the original contours of the ground. The amount of material moved was 2,000 cubic yards; the distance, very short. The shape of the filtering bed was made a little irregular to adapt it to the existing topographical conditions; but it is substantially a square, sub-divided into four small squares of one-quarter acre each by little embankments, three of which are about a foot in height; the fourth covers the pipe to a depth of three feet, for protection against freezing or other injury. To prevent the sewage from running off from the filtering bed without penetrating its surface, the filling was also embanked about a foot above the graded surface along the north-east side of the filtering bed, the only portion of the exterior line where the graded


OUTLET IN MIDDLE OF FILTERING BED
SCALE
INCHES
0
5 FEET
2 METERS
DIMENSIONS ARE FIGURED IN OLD MEASURES
CESSPOOL
81.96
OUTLET 78.
73.28
WATER LINE
INLET
SECTION
8 FEET
8"
INLET
OUTLET
8 FEET
PLAN
PIPE EMBANKMENT
SECTION THROUGH OUTLET ON A-B-C
GATE
12"
B
SECTION
1 FT
SUBDIVIDING EMBANKMENT
STONE PITCHING
A
GATE
GATE WAY
B
C
PIPE EMBANKMENT
GATE
GATE
10"
10"
1 FT
4 FT
PLAN

surface was not lower than the ground adjacent. The material is mostly gravel and stones from the size of a man's fist downwards, and is well suited for the purpose of filtration. In grading the filtering bed the thin stratum of loam and grass upon the surface was not removed; it was simply ploughed up and then handled like the gravel. But the narrow strip under the embankment through which the pipe is laid, had its loam stripped off, and the gravel with which it was replaced was carefully puddled to make an unyielding foundation for the pipe. At the middle of the filtering bed the pipe sewer ends, as shown on Plate III., in a wooden trough having four outlets, — one to each subdivision of the filtering bed, — which outlets are closed by three gates; so that the sewage runs on to one subdivision, and is shut off from the other three. Every other day the gate is changed from one outlet to the next, so as to turn two days' sewage on to a subdivision, and then give it six days' rest, to allow the sewage to pass off through the ground, and let the surface of that division become dry enough for another dose.

No underdrainage has been put in at the filtering bed. The ground water naturally is about ten feet below the surface of the filtering bed. Judging from the visible indications, especially the contour of the surface of the ground, the natural drainage from the filtering bed must be in the direction of a little depression leading down toward the meadow to the northward, where there is a spring of very good water which is the source of a permanent stream, as shown on the plan and profile. The artificially straight course of the little stream may be explained by the fact that the meadow through which it flows was graded up several years ago, so that better crops could be cultivated. This stream being a tributary of Charles River, upon whose banks a long distance below are situated the filtering galleries from which several municipalities draw their water supply, Medfield sewage requires to be purified before entering it. To determine as to the purification accomplished, chemical and biological examinations of the spring-water and other water in the vicinity have been made by the State Board of Health, as shown in the tables herewith.

ANALYSIS OF WATER AND SEWAGE AT MEDFIELD, MASS.

[PARTS IN 100,000.]

Wells Presumably Unaffected by the Filtering Bed.

Number.	Date, 1887-8.	Appearance.		Odor.		Residue on Evaporation (Unfiltered).				Ammonia.		Chlorine.	Nitrogen as Nitrites and Nitrates.	Nitrites.	Elevation of Water Surface.
		Turbidity.	Color.	Cold.	Hot.	Total.	Loss on Ignition.	Fixed.	Odor on Ignition.	Free.	Albuminoid.				
1034	Oct. 25,	Slight. Some grassy, flocky sediment.	None, .	Very faint or none.	Very faintly wooden.	7.70	1.20	6.50	Slightly disagreeable.	.0132	.0148	.47	.150	None, .	–
1035	Oct. 25,	Very slight. Considerable earthy and flocky sediment.	None, .	Distinctly straw-like and somewhat mouldy.	Distinctly musty.	9.47	2.95	6.52	Acid and somewhat disagreeable.	.0000	.0116	.70	.520	None, .	66.
1036	Oct. 25,	Very slight. A little light flocky sediment.	None, .	Very disagreeable.	Very disagreeable.	4.40	0.45	3.95	Very faint or none. White residue.	.0000	.0060	.27	.008	None, .	66.
1296	Nov. 30,	Slight. Much earthy and dark brown flocky sediment.	Very faint,	Very faint or none.	None, . .	5.60	0.70	4.90	Faintly acid, .	.0014	.0054	.42	.003	Present,	63.
1666	Jan. 23,	Clear. Very little sediment.	None, .	None, . .	Very faint or none.	4.50	0.90	3.60	Faintly acid, .	.0000	.0033	.38	.065	Present,	63.

Sewage.

Number.	Date, 1887-8.	Turbidity.	Color.	Odor, Cold.	Odor, Hot.	Total.	Loss on Ignition.	Fixed.	Odor on Ignition.	Ammonia, Free.	Ammonia, Albuminoid.	Chlorine.	Nitrogen as Nitrites and Nitrates.	Nitrites.	Elevation of Water Surface.
1033	Oct. 25,	Opaque. . .	Black, .	Sewage, . .	Sewage, .	45.90	16.00	29.90	Acid and offensive.	.0200	.3860	1.48	–	–	75.
1294	Nov. 30,	Opaque, . .	Black, .	Sewage, . .	Sewage, .	90.30	46.80	43.50	Very offensive,	.8520	1.570	2.67	.008	–	75.
1667	Jan. 23,	Opaque, . .	Blue black,	Sewage, . .	Sewage, .	62.50	18.50	44.00	Very offensive,	.4240	.3180	2.60	.015	Present,	75.

Spring containing Effluent from the Filtering Bed.

649	Aug. 29,	Clear, . . .	None, .	Faintly straw-like.	Very faint or none.	11.80	0.95	10.85	Peaty. Brown residue.	.0006	.0026	1.14	.195	None, .	62.
1295	Nov. 30,	Clear. No sediment.	None, .	Very faint or none.	None, . .	16.00	3.10	12.90	Decidedly acid,	.0000	.0024	1.63	.250	None, .	62.
1665	Jan. 23,	Clear, . . .	None, .	None, . .	Very faint or none.	15.40	2.60	12.80	Faintly acid, .	.0004	.0043	1.33	.300	Present,	62.

No. 1034. From well in hen-house. It had not been used since about Sept. 6, 1887, on account of failure of pump. This sample was taken immediately after repairs of pump. Disinfectant is used in the hen-house and is very conspicuous to the smell.

No. 1035. From well near Frairey Street not recently used. Half a pailful of water from another source was poured in to moisten the valves of the pump.

No. 1036. From well near the barn.

Nos. 1296 and 1666. From disused well near spring. Water is shallow, and it is not easy to get sample without some sediment.

No. 1033. About twenty people in the straw works. Some vats were emptied at the dye-house at a time to contribute to this sample. Of the residue on evaporation, 8.80 parts in 100,000 were suspended matters, 37.10 parts in 100,000 were in solution.

No. 1294. Dye-house and bleachery in full blast. About 400 people in the straw shop. Of the residue on evaporation, 10.90 parts in 100,000 were suspended matters, 79.40 parts in 100,000 were in solution.

No. 1667. About 750 people in the straw works. Work more active than ever before.

Nos. 649, 1295 and 1665. The temperature of the spring-water, Nov. 30, 1887, was 46° F., that of the air being 30° F.; on Jan. 31, 1888, it was 41° F., that of the air being 27° F.

BIOLOGICAL EXAMINATION.

Samples collected Feb. 24, 1888, were tested by the method of plate culture, and the number of bacteria per cubic centimeter was estimated thus:—

In water from disused well near spring,	98
In sewage from the sewer outlet (three samples),	1,046,400 to 1,320,000
In water from the deepest part of the spring (two samples, with twenty-one minutes' interval),	560 and 114
In water from the brooklet, forty feet down stream from the spring,	17,531

Surface water was running into the spring and into the brooklet along forty feet of its course below the spring; this probably accounts for the difference between the two samples from the spring, and for the enormously greater number of bacteria from the brook sample. Stable manure was spread over the meadow in the fall of 1887.

The samples of sewage were taken from the outlet in the middle of the filtering bed. To determine the quality of unpolluted ground water, samples were taken from several wells in the vicinity, whose positions are shown on the plan. Much the most useful one for the purpose is the one (Nos. 1296 and 1666) near the spring, from which it is seventy-eight feet distant; the surface of the water in this well was observed to be about one and seven-tenths feet higher than in the spring. Moreover, the contour of the ground would lead one to suppose that the natural direction of percolation under ground is from the well toward the spring. There are no buildings near and the well is out of use. The spring existed before the sewerage, and has a considerable water-shed to draw from; but that some of the effluent from the filtering bed now mingles with its waters is very plain from the analyses, the first of which was made after the works had been in operation nearly nine months; the excess, in all the analyses, of residue, chlorine and nitrates in the spring-water as compared with the well-water, and also their variation in the different analyses of the spring-water show it. As the proportion of chlorine in the spring-water is not far from a mean between that in the well-water and that in the sewage, it may be inferred that about half of the flow from the spring comes from the sewage and about half from the soil, for it is found that chlorides pass through sand filters unchanged. The quantity of water flowing visibly from the spring appears to be less than is discharged from the sewer, so that a portion of the outflow must take place beneath the ground. The comparison of the sewage and spring-water analyses in respect to ammonia and nitrates shows not mere dilution, but purification; the free ammonia and albuminoid ammonia, found in large quantity in the sewage, represent organic nitrogenous matter; oxidation converts the nitrogen into the inorganic form of nitrates, and it is these which are found in the spring-water in very much greater proportion than in the sewage, while from the spring-water the ammonia has almost disappeared. In respect to ammonia the spring-water compares favorably, not only with well-water as given in this table, but with public water supplies, including many that are drawn from the ground. Neither

sight, taste nor smell detects anything objectionable in the spring-water. That purification takes place in winter as well as in summer is shown by the last analysis, Jan. 23, 1888.

Record of Temperature of Medfield Sewage for the Month of December, 1887.

Day.	Hour.	Temperature. Degrees Fahr.		Day.	Hour.	Temperature. Degrees Fahr.	
1	12 M.	81		17	11 A. M.	76	
2	7 A. M.	72		18	10 A. M.	55	Sunday.
3	12 M.	82		19	12 M.	75	
4	10 A. M.	58	Sunday.	20	5 P. M.	72	
5	4 P. M.	80		21	12 M.	74	
6	12 M.	70		22	6 P. M.	70	
7	12 M.	75		23	6 P. M.	71	
8	7 A. M.	60		24	4 P. M.	71	
9	12 M.	75		25	2 P. M.	53	Sunday.
10	7 A. M.	65		26	2 P. M.	51	Holiday.
11	10 A. M.	57	Sunday.	27	7 P. M.	66	
12	12 M.	75		28	8 A. M.	72	
13	5 P. M.	74		29	12 M.	70	
14	5 P. M.	70		30	12 M.	68	
15	1 P. M.	78		31	7 A. M.	65	
16	12 M.	72					

The success of this filtering bed during the severe cold of winter has been favored by the fact that the dye-vats are kept at a high temperature. Daily observations in October, November, December and January, 1887–88, show that the temperature of the sewage as it comes upon the filtering bed at the outlet is, while business is active at the straw works, generally from 60° to 80° F., falling at night and on holidays from that downward to about the temperature of the ground water, say 50° F. A copy of the December record is annexed. In January, 1887, on a day when the thermometer went down to 26° below zero F., the sewage was turned on to a division of the filtering bed that was covered with snow and ice. The writer visited it a few days later and found that from a strip five or ten feet wide, extending

nearly across the bed, the snow and ice had been melted away. The sewage had also run underneath the remaining snow and ice a little way, so that on digging with a shovel through it — say ten feet from this open place — moist and unfrozen ground was found beneath; still further away the ground was frozen.

With regard to the quantity of liquid discharged upon the filtering bed, it was estimated in the latter part of 1887 by putting a little weir at one of the wooden trough outlets and observing at intervals the height of water going over it. It fluctuates a great deal, but it is estimated that in addition to the leakage of 2,000 cubic feet per twenty-four hours, of clean water above mentioned, there comes in on the average, from the straw works and the house drains, about 3,000 cubic feet per day for six days in the week for about seven months, from November to May, that is, about half the days in the year; but only about 1,500 cubic feet per day for five months, from June to October, and on Sundays in the other seven months, i. e., the other half of the year. That this estimate (though not claiming to be minutely accurate) is substantially correct may be judged by comparing such estimates as can be made from known facts as to the number of people in the buildings and the quantities usually discharged from the dye-house and bleachery; also by comparing the estimated quantity of water pumped from an artesian well which is the original source of most of the liquid that gets into the sewer. Most of what is pumped from this well ultimately finds its way into the sewer. More has been pumped heretofore than the required water supply, and the excess has been allowed to overflow from a tank and escape into the sewer, making just so much unnecessary hindrance to the drying of the filtering bed; whereas, if pumped at all, it might better have overflowed into Vine Brook, being pure water. For purposes of comparison the quantity of liquid discharged upon this filtering bed of one acre (or 4,000 square meters) may be estimated at 4,250 cubic feet (or 120 cubic meters, or 32,000 United States gallons) per twenty-four hours the year round, though the actual want of uniformity must make the effect rather different. For the purpose of comparison as to the population provided for, we

may assume, as an approximation, that the manufacturing waste from the straw works takes the place of the domestic waste that would ordinarily go with the number of operatives that board outside of the sewered area; and thus counting operatives and residents alike, may call the average population provided for about 500.

The works were designed for about 3,000 to 3,500 cubic feet of sewage per twenty-four hours; but the town secured an additional acre of ground around the present graded filtering bed with a view to extending its area, if an increase in the quantity of sewage to be disposed of should hereafter make it necessary. At present the full area prepared is not fairly availed of, because from the neglect to grade the surface more accurately by a little harrowing there are portions which stand high and dry and have never been touched by the sewage, which collects in the low places where, after two days' discharge, it stands in a pool. The six days following hardly give sufficient opportunity for it to percolate through the soil, and for the surface of the filtering bed to become dry. The natural tendency is toward the formation of a moist, pasty coating over the surface of the lowest points of the filtering bed, entirely contrary to the intention with which it was laid out. In spite of this imperfection, which it is not to be supposed will be allowed to continue, the general working of the scheme has been highly satisfactory. No smell is noticeable except just at the outlet of the sewer.

The work for the town was done under a contract for a "lump" sum; the cost of the disposal works was probably about $1,000, including cesspool, pipe from cesspool to outlet, earthwork, engineering, superintendence and profit to contractor, and the value of the land, which was given to the town. The annual expense of maintenance of the work of disposal is insignificant, — probably about thirty dollars. A man has to change the gate regularly, which is the principal labor required. The surface ought to be harrowed over when it gets clogged with sediment, the embankments repaired if they get trodden down or washed, the wooden parts will have to be occasionally renewed as they decay, the cesspool will have to be emptied sometime; but a very

few days' labor annually will cover all that appears to be required.

To conclude, these works on a small scale furnish an instructive example of the feasibility of disposing of sewage upon land under favorable conditions without nuisance, with very slight annual expense, and with thorough purification of the effluent. The successful working in the winter of this sewage disposal is somewhat less valuable as a precedent for other places, because of the exceptionally high temperature of this sewage.

FOOD AND DRUG INSPECTION.

REPORT OF THE STATE BOARD OF HEALTH TO THE LEGISLATURE,

As required by Chapter 289 of the Acts of 1884.

INSPECTION OF FOOD AND DRUGS.

Office of the State Board of Health,
13 Beacon Street, Boston.

Hon. Halsey J. Boardman, *President of the Senate of Massachusetts.*

Sir: — I have the honor to present herewith to the Legislature the Report of the State Board of Health relative to the inspection of food and drugs, in compliance with the provisions of section 2 of chapter 289 of the Acts of 1884.

Respectfully, your obedient servant,

SAMUEL W. ABBOTT,
Secretary State Board of Health.

REPORT.

The work which has been done by the Board during the past year under the provisions of the Food and Drug Acts has been quite similar in its character to that of the previous years since the first enactment of the law. The same methods which had been previously adopted and pursued under the provisions of the statutes have been carried out during the year, with such improvements as were suggested from time to time by the exigencies which have arisen in dealing with special cases.

As a matter of convenience, and also in consequence of the special provision of the act requiring that three-fifths of the appropriation shall be expended in the enforcement of the laws relating to milk and milk products, the subject will be treated under the different topics of

1. Food, other than Milk.
2. Milk.
3. Drugs.

No changes have been made in the corps of chemists employed by the Board during the year, the work of analysis having been efficiently conducted as in former years at the Laboratory of the Harvard Medical College, at Dr. Davenport's Laboratory on Tremont Street, and also at Prof. Goessmann's Laboratory at Amherst.

The system of indexing and cataloguing the samples has been continued in the same manner as before, and is found to be very convenient, not only as a method of classification but also as a means of reference in the search for special cases, where questions arise as to the identification of samples, or the accuracy of examination.

The routes pursued by the inspectors in their collection of samples were continued unchanged through the first

three years of work under these acts. For prudential reasons these routes were changed during the past year, the inspector who had visited the northern portion of the State being instructed to select his routes in the southern portion, and *vice versa.*

As in former years the collections have been made mainly from the cities and large towns. So far as milk is concerned, the smaller towns are practically free from any suspicion of adulteration as affecting its sale within their own limits.

The following summary presents the number of samples of food and drugs examined for the year ending Sept. 30, 1887, together with the number of each sort found to be adulterated and the number free from adulteration : —

Number of samples of food examined,	4,870
" " " found to be pure,	3,163
" " " adulterated or not conforming to the statutes,	1,707
Percentage of adulteration,	35.05
Number of samples of milk (included above),	3,081
" " " " " above standard,	1,900
" " " " " below standard, or otherwise adulterated,	1,181
Percentage of adulteration,	38.33
Number of samples of drugs,	550
" " " " " of good quality,	400
" " " " " not conforming to the statutes,	150
Percentage of adulteration,	27.27
Total examinations of food and drugs,	5,420
" " of good quality,	3,563
" " not conforming to the statutes,	1,857
Percentage of adulterations,	34.26

A further summary is also presented for the purpose of comparison with the work of previous years : —

SUMMARY.	Years. 1883.	1884.	1885.	1886.	1887.	Totals.
Number of samples of food examined,	695	1,962	3,771	3,438	4,870	14,736
" " " found to be pure,	363	779	2,180	2,186	3,163	8,671
" " " found to be adulterated or not conforming to the statutes,	332	1,183	1,591	1,252	1,707	6,065
Percentage of adulteration,	47.8	60.3	40.3	36.4	35.1	41.2
Number of samples of milk examined (included above),	218	1,123	2,219	2,085	3,081	8,726
" " " above standard,	35	347	1,297	1,323	1,900	4,902
" " " below standard,	183	776	922	762	1,181	3,824
Percentage of adulteration,	83.9	69.1	41.7	36.5	38.3	43.8
Number of samples of drugs examined,	603	682	1,007	888	550	3,730
" " " of good quality,	357	431	571	463	400	2,222
" " " adulterated as defined by the statutes,	246	251	436	425	150	1,508
Percentage of adulteration,	40.8	36.8	43.3	47.8	27.3	40.4
Total examinations of foods and drugs,	1,298	2,644	4,778	4,326	5,420	18,466
" " " " of good quality,	720	1,210	2,751	2,649	3,563	10,893
" " " " not conforming to the statutes,	578	1,434	2,027	1,677	1,857	7,573
Percentage of adulteration,	44.5	54.2	42.4	38.7	34.3	41.0
Expense of collection, examination and prosecution,	$2,931 56	$5,529 60	$8,557 43	$8,025 34	$8,803 62	$33,847 55
" " " per sample,	2 26	2 09	1 79	1 85	1 62	1 83

Attention is specially called to the comment of the food analyst concerning the comparative amount of adulteration detected during the past year, as compared with that of former years.

The percentage of adulterated articles therein stated as having been found in the samples collected in 1887 was 29.7, being the lowest of any year since the Food and Drug Acts went into operation. The actual difference between this percentage and that of previous years is greater than the apparent difference, as shown in the statistics presented for each year, for the reason that in the earlier years samples of food were collected from a greater variety of articles. The experience of the past few years has enabled the Board to omit many articles in the work of collection, such experience having shown that many staple articles are practically free from adulteration. The percentage of adulteration found by the analysts is therefore a percentage of articles liable to adulteration, and not that of the general food supply.

The work of the first year or more under the laws relative to food and drug inspection must be considered as preliminary and tentative only, and was conducted with special reference to ascertaining the actual condition of the various supplies of food and drugs offered for sale in the State, with reference to the prevalence of adulteration.

Many difficulties were encountered in the first year's work with reference to the methods to be adopted for the collection of samples, and the routine of work necessary for the most efficient execution of the laws. No complaints were entered for prosecution until the last month of that year, and in a comparative estimate of the operations of different years it is no more than fair to reject the limited and merely preliminary work of the first year.

The actual percentage of the articles found to be adulterated in the different years of the operation of these acts (excepting 1883) is as follows: —

Percentage of adulteration,	1884, ...	54 2 per cent.
" " "	1885, ...	42.4 " "
" " "	1886, ...	38.7 " "
" " "	1887, ...	34.3 " "

It should not be understood that these figures in any year represent the actual amount of adulteration which exists among the different articles which are under the supervision of the laws, for the reasons already stated.

The actual benefits derived from the operation of these statutes have already been alluded to in previous reports, and the estimates therein given do not require a repetition here, except to say that the actual gain to the consumer has many times exceeded the cost of execution of the laws.

The benefit is mainly an economical one, inasmuch as the forms of adulteration are chiefly of a commercial character. Injurious forms of adulteration, however, are special objects of search, and there can be no question that sanitary advantages are secured by the general operation of the law.

In certain articles of food which have been specially liable to fraud, such as the various sorts of spices, condiments, cream of tartar, etc., adulteration has been greatly diminished, and is in many instances limited to parties whose business is conducted outside of the State, and cannot therefore be easily reached except through the customary notice sent to the retailer who buys of such outside parties.

These notices have proved to be a very efficient mode of diminishing adulteration. It is not the retailer who is seriously affected by the receipt of such a notice, but the wholesale dealer or manufacturer to whom it is speedily forwarded by the retailer, and who finds that he cannot afford to continue in wholesale imposition.

The total number of samples of food and drugs of all kinds examined during the year was 5,420, an increase of 642 over that of any previous year, the principal increase having been in the number of samples of milk. This increase was effected in order to secure a more explicit compliance with the provision of the statute requiring an expenditure of three-fifths of the appropriation in the enforcement of the laws relative to milk and milk products.

A reasonable degree of improvement in the results attained by the execution of the statutes has been accomplished, and if constant improvement from year to year in all directions is not secured, it is certainly a great gain to be able to prevent further adulteration, and to require a reasonable

conformity to standards of purity and excellence. So long as avarice, carelessness, neglect and ignorance are common characteristics of mankind, some sort of inspection must be maintained as a safeguard against harm on the one hand and fraud on the other.

Food.

The different articles of food which have been collected by the inspectors from all parts of the State, and submitted to examination or analysis for the purpose of determining their quality, have been mainly those which are subject to adulteration, the previous work of this Board in this department of investigation having conclusively shown that many staple articles of food are not subject to fraud, at least so far as their sale in this State is concerned.

The following list will show the number of samples of each different article examined : —

Allspice,	36	Horseradish,	2
Essence of almond,	4	Jam,	3
Arrowroot,	1	Lard,	18
Baking powder,	21	Maple sugar,	13
Canned vegetables,	31	Maple syrup,	7
Bread,	1	Mapleine,	2
Butter,	104	Macaroni,	2
Cake,	1	Molasses,	97
Cayenne,	27	Mace,	20
Cassia,	103	Mustard,	118
Cinnamon,	13	Pepper, black,	144
Celery salt,	6	Pepper, white,	70
Cheese,	21	Pimento,	12
Chocolate,	5	Pickles,	1
Cider jelly,	2	Olive oil,	17
Cloves,	60	Nutmeg,	5
Coffee,	11	Sage,	5
Cocoa,	6	Savory,	2
Corn starch,	3	Soda,	16
Candy,	45	Sugar of milk,	1
Cream of tartar,	198	Sugar,	8
Curry powder,	2	Powdered sugar,	6
Custard powder,	1	Thyme,	3
Ginger,	123	Tea,	28
Gelatine,	6	Vinegar,	224
Ginger ale,	3	Yeast,	8
Honey,	32		

From this list it will be seen that the articles chiefly selected for examination from the food markets of our State are the different sorts of spices, baking powders, cream of tartar, honey, lard, molasses and syrups, olive oil, vinegar and canned or preserved vegetables. Those which comprise the larger numbers in this list are the articles most liable to adulteration.

Coloring-Matter in Food.

The law of 1882 is quite explicit in its provisions for the prevention of the coloring of food, the following section of the law applying to this subject: —

Chapter 263, Acts of 1882, section 3, clause *b* (6).

An article shall be deemed to be adulterated within the meaning of this act, —

(*b*.) In the case of food,—(6) If it is colored, coated, polished or powdered, whereby damage is concealed, or if it is made to appear better or of greater value than it really is.

The practice of employing coloring-matters in connection with different articles of food is very common. The following may be named as very common examples: —

Certain condiments, such as mustard, ginger and other spices, sugar, confectionery, preserved and canned goods, especially peas and beans, milk, butter, oleomargarine, pickles, cake, syrups, and various sorts of beverages.

The coloring-matters employed in connection with these articles of food may be classified as follows: —

1. *Harmless colors.* These are usually made from some comparatively harmless organic products, such as annotto, caramel, turmeric and cochineal.

2. *Injurious colors.* These are usually some of the metallic compounds, such as lead, copper and tin.

It cannot be urged in regard to any of these colors, whether harmless or otherwise, that they have any true value as articles of food, and the demand for their use comes mainly from the trader, and not from the actual consumer, excepting so far as the latter has been erroneously educated by the former as to true color-standards in the matter of food.

No good and useful end is attained by their use, so far as the question of nutriment is concerned, and not only may

harm ensue, but also even fatal consequences, as in the recent cases which have occurred in Philadelphia from the use of poisonous compounds of lead.

The true use of artificial food colors is usually a fraudulent one, and they are consequently employed mainly for the purpose of giving to an inferior article of food a fictitious value, and thus to imitate other articles of a similar character, but of a better quality, at least so far as their actual cost is concerned. The difference in actual nutritive value as articles of food may, however, be but little or nothing.

The following articles of food named in the report of the food analyst deserve special attention : —

Canned Vegetables (chiefly beans and peas). — A considerable portion of these articles is imported from France, mainly from Paris and Bordeaux, and as will be seen in the report, two-thirds of the samples examined were found to be adulterated with copper which had evidently been introduced for the purpose of imparting to these vegetables a bright green color like that of the same kinds of food when used in the fresh state. Such sale being evidently in violation of the statutes, the parties selling them were notified that the sale was deemed to be made contrary to the law of 1882.

The limitation of the quantity of poisonous colors in articles of food is, to say the least, a matter of doubtful propriety, especially when the preparation of such forms of adulteration is conducted by irresponsible parties outside of the State, and as in this case outside of the country.

It is not proposed to discuss in this connection the actual effect of small quantities of metallic or other poisons when introduced into articles of food, either for coloring or for other purposes. The law already quoted is explicit upon this point, and is evidently based upon the principle that it is a safer course to exclude them altogether.

In this connection the recent German law is worthy of quotation, as bearing upon the question of coloring-matters in food.

Law of the German Empire (July 5, 1887) regarding the use of colors detrimental to health in food preparations, and in all articles for domestic use.

SECTION 1. Colors detrimental to health are not allowed to be used in the preparing of food and of other articles for domestic use intended for sale.

Colors injurious to health, within the meaning of this section, are those color substances and color preparations which contain antimony, arsenic, barytes, lead, cadmium, chromium, copper, mercury, uranium, zinc, tin, gamboge, coraline, picric acid.

The Chancellor of the Empire is empowered to issue particular directions about the processes to be used in the determination of the existence of arsenic and tin.

SECT. 2. For the preservation or packing of provisions and other domestic articles intended for sale, no vessels, envelopes or protecting coverings are allowed to be used, for the manufacturing of which, colors of the kind mentioned in section 1, clause 2, have been used.

This provision does not apply to the use of sulphate of barium (heavy spar, blanc fixe), of drop-colors of barytes, which are free from carbonate of barium, from chromic oxide, copper, zinc, tin, and of their combinations as metallic colors, from cinnabar, dioxide of tin (stannic oxide), sulphide of tin as mosaic gold, nor to any colors burnt into glass masses, glazings, enamels, or to the external painting of vessels of water-tight material.

SECT. 3. The elements mentioned in section 1, clause 2, are not allowed to be used for the manufacturing of cosmetic articles (means for the cleaning, improving or coloring of the skin, hair, or of the cavity of the mouth) which are intended for sale.

This provision does not apply to sulphate of barium (heavy spar, blanc fixe) greenockite, chromic oxide, cinnabar, oxide of zinc, oxide of tin, sulphide of zinc, nor to copper, tin, zinc and their combinations in the form of powder.

Section 4 has reference to the use of poisonous colors in the manufacture of toys, picture-books, etc.

Section 5 prohibits the use of arsenic in plates and lithographs in books.

Section 6 prohibits the sale of certain injurious inks.

SECT. 7. No colors containing arsenic are allowed to be used in the manufacture of paper hangings, furniture stuffs, carpets, materials for curtains or garments, masks, candles and artificial leaves, flowers and fruits intended for sale.

This regulation does not apply to the use of arsenical mordants or fixing agents for the purpose of the dyeing or printing of spun goods or textiles. Yet spun goods and textiles so made are not allowed to be used for the manufacturing of the objects named in clause 1, if they contain the arsenic in a form soluble in water, or in such a quantity that in 100 sq. c. m. of the finished object there are more than two milligrams of arsenic. The Chancellor of the Empire is empowered to issue particular directions about the processes to be used in the determination of the percentage of arsenic.

Sect. 8. The provisions of section 7 apply also to the manufacturing of writing materials, shades and screens, also of "light cuffs" intended for sale.

The manufacture of wafers falls under the provisions of section 1; yet, as far as they are not intended to be eaten, the use of sulphate of barium (heavy spar, blanc fixe), chromic oxide and cinnabar is allowed.

Sect. 9. Arsenical water and size-colors are not allowed to be used in the painting of floors, ceilings, walls, doors, windows of dwelling or business rooms, of folding, rolling or sliding shutters or curtains, of furniture and other articles of domestic use.

Sect. 10. The provisions of sections 2 and 9 do not apply to the use of colors which do not contain the elements named in section 1, clause 2, as constituent parts, but merely as sediment, and this at the most in a quantity unavoidable in the common technical proceedings.

Sect. 11. The provisions of this law do not apply to the dyeing of fur goods.

Sections 12, 13, 14, and 15 provide the penalties, etc., for violation of the foregoing sections.

Honey. — This substance, defined as "a product collected by bees from flowering plants," is quite commonly found to be, in its adulterated form, a product of human industry, having in its composition a small portion of honey, to which glucose has been added, or possibly some other form of syrup. Honey in the comb, sold in boxes, is usually free from adulteration, while that which is put up in glass jars or similar packages in the form of syrup, containing, in order to imitate the genuine article, small bits of honey-comb, and occasionally one or more bees to complete the illusion, is frequently adulterated. More than one-half of the samples collected were of this sort.

Molasses. — In addition to the adulteration of molasses with salts of tin, as mentioned in the report of last year, other forms of adulteration are also found to prevail, not, however, of an injurious character. These are mainly the adulteration with glucose. Six complaints were entered during the year for fraudulent sales of molasses, adulterated with glucose. In these cases convictions were secured in all, with one exception.

Baking Powders. — In the report of the food analyst will be found a further list of baking powders containing alum, in addition to those which have been published in previous reports.

Inasmuch as this class of food preparations is not limited by a statutory standard, action could only be taken in regard to such of them as might be shown to be injurious to health. Some of the ingredients employed in the composition of baking powders are known to have a poisonous action when administered in large doses. The question of their action in small doses, given either singly, or in repeated doses for a long period, is not so well settled. The amount of baking powder in a single loaf of bread is small; the amount of each ingredient is smaller; and the amount in the portion of bread consumed by a single individual at a meal is very small.

Since, however, bread is the most commonly used of all articles of food, and the long-continued use in small quantities, of such articles as in large quantities have decidedly injurious action, may prove harmful to the consumer, it is evidently the safer course at least to advise the consumer against the use of articles containing such ingredients, if not positively to prohibit their sale.

A very convenient classification of these preparations is given in the recent report of the Ohio Dairy and Food Commission, entitled, "Circular No. 6," in which they are divided into three groups, as follows: 1, Cream of Tartar Powders; 2, Phosphate Powders; 3, Alum Powders.

The commission makes the following statement with reference to certain ingredients of baking powders: —

In some brands of the cream of tartar baking powder a small per cent. of carbonate of ammonia is used; but this is considered

too small an amount to be hurtful. There is a prevalent belief created by the erroneous statement of manufacturers that the salts from which carbonic acid gas is generated pass off in the form of escaping gas, scarcely leaving a trace of their presence in the bread. But this is not true. These resultant salts, formed by the chemical action in the dough, remain in the bread, while the gas generated by such chemical action and which is but a small per cent. of the whole, alone passes off in the process of baking. From this fact many persons condemn the entire class of alum baking powder as unhealthful. Pure alum is undoubtedly a hurtful salt, and the resultant salts from its combination with soda can scarcely be less hurtful. And yet any number of conflicting opinions and certificates can be had from eminent chemists on either side of this question.

Butter. — Since the question of the adulteration of butter has been made the subject of a special order of the Legislature of 1887, the work of the Board in that direction will be found detailed in the report relative to oleomargarine, made in compliance with such order, in a later portion of this report.

Warning notices were issued to persons retailing articles of food found to be adulterated in the following cities and towns : —

Amherst,
Baldwinville,
Boston,
Brookline,
Cambridge,
Chelsea,
Clinton,
Cottage City,
Dedham,
Everett,
Fall River,
Fitchburg,
Franklin,
Gloucester,
Greenfield,
Haverhill,
Holyoke,
Hyannis,
Hyde Park,
Lawrence,
Lee,
Leominster,
Lowell,
Lynn,
Malden,
Marlborough,
Medford,
Milford,
Millbury,
Miller's Falls,
Natick,
Needham,
New Bedford,
Newton,
North Adams,
North Brookfield,
Orange,
Palmer,
Pittsfield,
Plymouth,
Reading,
Salem,
Spencer,
Springfield,
Stoneham,
Stoughton,

Taunton,	Webster,
Turner's Falls,	Westfield,
Waltham,	West Medway,
Ware,	Worcester.
Watertown,	

The articles of food found to be adulterated, and for which the notices were sent, informing the retail dealers of the fact of adulteration, were as follows: —

Allspice,	1	Maple sugar,	5
Baking powder,	1	Maple syrup,	2
String beans, canned,	5	Molasses,	10
Brussels sprouts, canned,	1	Mustard,	34
Butter,	6	Ground nutmeg,	1
Molasses candy,	3	Olive oil,	10
Cassia,	10	Peas, canned,	16
Cayenne,	8	Pimento,	1
Cloves,	5	Pepper, black,	42
Cream of tartar,	33	Pepper, white,	31
Ginger,	14	Vinegar,	86
Honey,	17	Dry yeast,	2
Lard,	11		
Mace,	5		360

Milk.

The work accomplished in the examination of milk has been greater than that of any previous year, the whole number of samples examined by the analysts and reported upon by them being 3,081. The cause of this increase has already been explained (page 117). The number of samples found to be below the standard was 1,181, or 38.3 per cent. of the whole, a result very nearly the same as that of the preceding year, while the percentage of adulteration found in 1885 was 41, and in 1884, 69 per cent.

No article of food is of greater importance than milk; no article is more liable to adulteration; and in the case of no article is it necessary to exercise more constant watchfulness for the prevention and the detection of fraud. The various causes and factors which contribute to the deterioration of milk have been considered in a previous report.* One of these, the length of time elapsing between the production and the consumption of milk, has also received special atten-

* Fifth Supplement, 1883, page 105.

tion by the Suffolk District Medical Society, which in a report upon the subject recommended that milk should be purchased by the consumer in the large eight and one-half quart cans in which it is usually brought to market, — by so doing the consumer would receive the benefit derived from avoiding the greater amount of handling, and consequent delay necessitated by the delivery in small packages.

The various manipulations to which milk is subjected in its transmission from the producer to the consumer render it in occasional cases a probable medium for the communication of infectious disease. Further reference to this important subject, together with the details of cases in illustration of it, may be found in the General Report of the Board, at page xxvi.

Greater immunity of the population of our large cities from epidemics of certain infectious diseases, such as typhoid fever, diphtheria and scarlet fever, would undoubtedly be secured by a careful inspection of all dairy-farms (which furnish milk to cities and towns), such as is authorized by the English law, quoted in the last report of the Board. This law includes many provisions of a sanitary character, such as the lighting, ventilation, drainage, water supply and general cleanliness of dairies, as well as other places where milk is stored or kept for sale.

In this connection attention is directed to the statement of Dr. Davenport relative to the use of annotto for the purpose of coloring milk, and of the filthy character of the compound as commonly used for this purpose. The vigorous action of the Board in suppressing this form of adulteration has had a healthful effect. The excuse so often given for its use, that the people demand it, cannot reasonably be urged, since this demand was first created and fostered by the dealers themselves.

The following summary comprises the results of analyses of milk obtained in the twenty cities of Eastern Massachusetts.

The number of samples of milk reported to have been artificially colored is probably considerably less than the actual number, since about half of the samples only were examined with special reference to this form of adulteration.

Milk obtained in Cities of Eastern Massachusetts.

Number of samples,	1,817
above standard,	1,045
below standard,	772
Percentage below standard,	42.49
Number of samples of skimmed milk sold as such,	14
Samples of colored milk,	36
condensed milk,	6

Boston.

Number of samples received.	367
above the standard,	163
below the standard,	192
Percentage of samples below the standard,	52.31
Skimmed,	11
Buttermilk,	1
Colored,	3
Lowest sample,	9 29

Condensed Milk — Result of Analysis, Six Samples.

Fat.	Solids not Fat.	Total Solids.	Water.	Ash.
8.88	29.72	38.60	61.40	2.05
8.50	29.30	37.80	62.20	2.00
8.25	29.50	38.75	61.25	1.80
7.70	27.40	35.10	64.90	1.80
6.10	29.55	35.65	64.35	1.65
8.40	27.20	35.60	64.40	1.70

Lowell.

Number of samples received,	99
above standard,	52
below standard,	47
Colored,	3
Lowest,	9.86
Percentage below standard,	47.47

Worcester.

Number of samples received,	154
above standard,	107
below standard,	46
Skimmed,	1
Colored,	1
Lowest,	11.34
Percentage below standard,	29.87

Cambridge.

Number of samples received,	288
above standard,	141
below standard,	147
Colored,	19
Lowest,	9.52
Percentage below standard,	51.04

Fall River.

Number of samples received,	96
above standard,	57
below standard,	39
Colored,	2
Lowest,	10.00
Percentage below standard,	40.62

Lynn.

Number of samples received,	93
above standard,	37
below standard,	56
Colored,	3
Lowest,	10.30
Percentage below standard,	60.21

Lawrence.

Number of samples received,	72
above standard,	51
below standard,	20
Skimmed,	1
Lowest, not skimmed,	11.04
Percentage below standard,	27.77

New Bedford.

Number of samples received,	55
above standard,	47
below standard,	8
Lowest,	11.34
Percentage below standard,	14.54

Somerville.

Number of samples received,	74
above standard,	22
below standard,	51
Skimmed,	1
Lowest,	9.68
Percentage below standard,	68 92

Salem.

Number of samples received,	56
above standard,	40
below standard,	16
Colored,	1
Lowest,	10.86
Percentage below standard,	28.57

Chelsea.

Number of samples received,	121
above standard,	71
below standard,	50
Colored,	3
Lowest,	8.35
Percentage below standard,	41.32

Taunton.

Number of samples received,	24
above standard,	19
below standard,	5
Lowest,	11.62
Percentage below standard,	20.83

Haverhill.

Number of samples received,	57
above standard,	38
below standard,	19
Lowest,	11.22
Percentage below standard,	33.33

Gloucester.

Number of samples received,	26
above standard,	22
below standard,	4
Lowest,	10.46
Percentage below standard,	15.38

Brockton.

Number of samples received,	35
above standard,	31
below standard,	4
Colored,	1
Lowest,	11.50
Percentage below standard,	11.43

Newton.

Number of samples received,	37
above standard,	25
below standard,	12
Lowest,	11.22
Percentage below standard,	32.43

Malden.

Number of samples received,	51
above standard,	25
below standard,	26
Lowest,	10.36
Percentage below standard,	50.98

Fitchburg.

Number of samples received,	49
above standard,	40
below standard,	9
Lowest,	11.67
Percentage below standard,	18.37

Waltham.

Number of samples received,	29
above standard,	15
below standard,	14
Lowest,	8.94
Percentage below standard,	48.27

Newburyport.

Number of samples received,	34
above standard,	27
below standard,	7
Lowest,	10.98
Percentage below standard,	20.58

The following summary comprises the results of analyses of milk obtained in the towns of Eastern Massachusetts. Of these eight hundred and fifty-four samples, a small portion, probably not more than fifty, was obtained at the farms of producers suspected of milk adulteration.

The percentage of adulteration in the towns is about ten per cent. less than that found in the cities of the same portion of the State.

TOWNS.	Total Number of Samples.	Number Above Standard.	Number Below Standard.	Percentage Below Standard	Skimmed.
Athol,	13	13	-	-	-
Attleborough,	14	12	2	14.29	-
Baldwinville,	9	7	2	22.22	-
Beverly,	38	20	18	47.37	-
Brookline,	10	7	3	30.00	-
Canton,	11	10	1	9.09	-
Chelmsford,	10	10	-	-	-
Chelsea,	61	42	19	31.15	-
Clinton.	42	31	11	26.19	1
Concord,	12	1	11	91.67	-
Cottage City,	13	8	5	38.46	-
Dedham,	8	1	7	87.50	-
Everett,	16	6	10	62.50	-
Franklin,	9	7	2	22.22	-
Gardner,	13	9	4	30.77	1
Hardwick,	21	2	19	90.48	-
Hyde Park,	49	34	15	30.61	-
Leominster,	50	32	18	36.00	-
Manchester,	6	3	3	50.00	-
Marblehead,	11	4	7	63.64	-
Marlborough,	7	6	1	14.29	1
Maynard,	1	1	-	-	-
Medford,	25	16	9	36.00	-
Melrose,	23	20	3	13.04	-
Milford,	38	34	4	10.53	-
Millbury,	9	8	1	11.11	-
Nantucket,	3	3	-	-	-
Natick,	40	31	9	22.50	-
Northborough,	22	15	7	31.82	-
North Brookfield,	11	8	3	27.27	-
Peabody,	8	6	2	25.00	-
Plymouth,	8	6	2	25.00	-
Provincetown,	12	10	2	16.67	-
Quincy,	7	6	1	14.29	-
Southborough,	8	6	2	25.00	-
South Framingham,	11	8	3	27.27	1
Spencer,	12	9	3	25.00	-
Still River,	7	1	6	85.71	-
Stoneham,	26	11	15	57.69	-
Stow,	7	5	2	28.57	-
Sudbury,	27	15	12	44.44	-
Tyngsborough,	6	6	-	-	-
Wakefield,	11	8	3	27.27	-
Watertown,	30	22	8	26.67	-
Webster,	15	8	7	46.67	-
Westborough,	29	21	8	27.59	-
Winthrop,	10	7	3	30.00	-
Woburn,	25	21	4	16.00	-
	854	577	277	32.44	-

The following list comprises the cities and towns to which notices were sent to retail dealers found selling milk below the standard, with the number sent to each city or town : —

Andover,	2	Millis,	2
Attleborough.	2	Natick,	4
Baldwinville,	2	Newburyport,	3
Beverly,	5	New Bedford,	4
Boston,	61	Newton,	2
Brockton,	1	Northampton,	1
Cambridge,	52	Northborough,	1
Canton,	1	North Brookfield,	1
Chelsea,	12	Peabody,	1
Cottage City,	1	Quincy,	1
Dedham,	3	Salem,	5
Everett,	2	Somerville.	19
Fall River,	15	South Framingham,	2
Fitchburg,	1	Southborough,	1
Gloucester,	2	Springfield,	1
Haverhill,	2	Still River,	1
Hyde Park,	5	Stoneham,	2
Lawrence,	3	Taunton,	1
Leominster,	2	Wakefield,	3
Lowell,	10	Waltham,	5
Lynn,	13	Watertown,	5
Malden,	4	Webster,	2
Manchester,	3	Westborough,	1
Marblehead,	3	Winthrop,	4
Medford,	1	Worcester,	5
Melrose,	2		
Milford,	2		290
Millbury,	1		

The statistics relative to the inspection of milk in the cities and towns of Western Massachusetts will be found at the close of this report.

Drugs.

The examinations of drugs made through the past yea. show a greater improvement than that of either of the othei classes which come within the provisions of the acts relative to inspection, and this is still more manifest when it is known that the collection of samples has been even more closely limited than before to articles liable to adulteration. So great has been the improvement brought about by the administration of the law with reference to drugs, that

whereas it was difficult to find the stronger preparations of opium conforming to the pharmacopœial standard previous to the enforcement of the Act of 1882, at the present time such departures from the standard are the exception rather than the rule.

In 1883, in a collection of one hundred samples of tincture of opium collected in different parts of the State, there were 82 per cent. of the number which fell below the standard requirement of at least 1.20 per cent. of morphine. In a similar collection made during the past year the number of samples falling below the standard was but 21.4 per cent.

It was predicted that great danger would follow the requirement that such preparations should uniformly conform to the standard laid down in the statutes, and that an alarming fatality would be sure to ensue, especially in view of the fact that the opium preparations are among the most valuable and widely used of the officinal articles. No such result, however, has followed, and the Registration Reports and the returns of medical examiners give ample proof of this statement.

There are certain articles, however, which still show a lamentable deficiency in meeting the requirements of the Pharmacopœia. Of these, the most marked instance is found in the compound spirits of ether, and it may be reasonably inquired whether the limited use of this preparation, once so highly valued, may not be due to the habitual omission of its most essential ingredient, the ethereal oil.

The same remark is also applicable to the pharmacopœial spirits and wines,— four in number,— brandy, whiskey, red and white wines. The two latter are rarely prescribed or called for under these names, and when they are called for it is also quite as rare to obtain a genuine unadulterated product.

The wines and spirits which have been inspected under the authority of the Food and Drug Acts have been submitted to examination with reference to their use as drugs, and not as beverages, and hence the United States Pharmacopœia of 1880 has been followed as the standard of requirement.

The Pharmacopœial Wines.

The limit of alcohol allowed for officinal wines is twelve per cent. by weight, which appears to be confirmed by the examinations made by the National Department of Agriculture, at Washington, which publishes the following statement: —

Any wine with a higher percentage of alcohol than fifteen per cent. by volume (twelve per cent. by weight) can be safely declared to be fortified, for it has been shown that fermentation is arrested when the alcoholic content reaches about that point.*

Notwithstanding this statement, it is not uncommon to find wines in which the amount of alcohol found is frequently as high as twenty per cent. by weight, and occasionally a higher amount, instead of twelve per cent.

Attention is especially called to the statement of the analyst of drugs with reference to this subject.

From the report just quoted it appears that adulteration of wines has kept pace in this country with the rapid growth of their production.

The comparative consumption of American and foreign wines in the United States is shown by the following figures: —

Wines Consumed in the United States.

Year ending June 30.	Wines of Domestic Product.	Imported Wines entered for Consumption.	Total.
	Gallons.	Gallons.	Gallons.
1840, ...	124,734	4,748,362	4,873,096
1850, ...	221,249	6,094,622	6,315,871
1860, ...	1,860,008	9,199,133	11,059,141
1870, ...	3,059,518	9,165,549	12,225,067
1880, ...	23,298,940	5,030,601	28,329,541
1886, ...	17,366,393	4,700,827	22,067,220

* United States Department of Agriculture, Division of Chemistry, Bulletin No. 13, part third, page 356.

The following table represents the percentage of adulteration found in wines examined by the State Board with reference to the requirements of the Pharmacopœia : —

Whole number examined, ...	70
Number having an excess of alcohol, ...	52
Number having an excess of solid residue, ...	52

The two latter items do not necessarily represent the same samples.

Upon this standard all of the samples of port and Madeira examined by the analyst of the Board were found to be fortified, without exception.

The Board receives the valuable monthly reports of the Paris Municipal Laboratory, giving the summary of their examinations for each month. From these reports the following table is compiled, which indicates the extent of adulteration found in the wines offered for sale in the city of Paris during the year 1887 : —

INSPECTION OF WINES — *Table compiled from Monthly Reports of Paris Municipal Laboratory, 1887.*

1887.	Number of Samples Ana'yzed.	Good	Diseased (acid, bitter, mouldy, cloudy, etc).	Wines Plastered above 2 grams.	Watered.	Sugared or Fortified.	Artificially Colored.	Salicylated.	Salted or Deplastered.	Piquette.
January,	712	292	37	83	14	48	41	24	6	3
February,	748	348	49	96	162	54	2	7	5	43
March,	936	365	46	177	207	122	3	21	8	39
April,	729	312	37	99	166	72	5	22	3	38
May,	698	322	32	99	138	55	9	60	4	33
June,	560	182	43	95	148	79	-	15	2	51
July,	623	236	41	67	148	44	1	7	9	66
August,	579	208	52	99	138	52	-	5	-	87
September,	536	190	44	68	145	39	4	10	-	66
October,	555	187	43	86	159	65	11	4	2	87
November,	585	225	43	89	142	66	16	2	2	64
December,	664	204	38	121	162	63	3	1	-	99
Total,	7,925	3,071	505	1,179	1,729	760	95	178	41	676
Per cent.,	-	-	6.37	14.87	21.82	9.59	1.19	2.25	0.52	8.53

The following authentic information relative to the adulteration of sherry wine is copied from a recent letter written by the mayor of Jerez de la Frontera, the seat of the sherry wine district: —

It is a fact that more butts are exported every year under the name of sherry than the district produces, and yet the legitimate product has no sale, and the spurious wines usurping their titles injure the fame acquired through centuries. . . .

The great variety of brands of complex mixtures, of names and imitations, has introduced the greatest confusion in the business. Certain cellars look like mysterious laboratories, whose secrets nobody is allowed to penetrate, and hence comes that infinite variety of prices. What can be assured is, that the finer grades — the genuine sherry — have necessarily only to maintain a value which will never allow it to become confounded with those liquids, which are to-day the principal brands for exportation.*

The subject of the importation of German alcohol and its use in fortifying Spanish wines is further mentioned in the report of Consul Ingraham, who states that German alcohol is inferior in quality to Spanish alcohol, and has driven all other alcohol from the market throughout Spain, the amount of its importation being $12,000,000. It injures the reputation of Spanish wines for purity, and affects the general health by their adulteration.

The Distilled Liquors of the Pharmacopœia.

Of the twenty samples of brandy and whiskey which were examined, one only, and that a sample of whiskey, was found to conform to the requirement. (Later examinations, made since October 1, have shown considerable improvement with reference to the quality of whiskey examined.)

The following statement, made by an expert, confirms the experience of the analyst of the Board with reference to brandy as sold to the consumer, and the statement unfortunately applies to the pharmacist as well as to dealers in liquors: —

The term "brandy" seems to be no longer applied to a spirit produced by the fermentation of grapes, but to a complex mixture,

* United States Consular Reports, November, 1887, p. 333.

the alcohol of which is derived from grain, potatoes, or, worst of all, the refuse of the beet-sugar refineries. It would seem to be fairly impossible at present to purchase a pure cognac, as each individual proprietor of a vineyard has become a distiller and compounder. He has acquired the art of imitating any special flavor or vintage of brandy that may be called for. Potato spirits and beet alcohols, the most deleterious and obnoxious of all the varieties of spirits, are sent from Germany into France in vast quantities. They are flavored, colored, and branded or labeled to meet the wishes of American connoisseurs. The mere fact of coming out of bond, or "straight through the custom house," is generally accepted here as sufficient evidence that they are pure and genuine. It is rather unfortunate that physicians themselves frequently strengthen this hallucination in favor of imported spirits by giving the most stringent orders to their patients to procure genuine French cognac, even though it may command tenfold the price of an absolutely pure spirit of domestic production. This imperative command becomes a cruel injustice in the case of poor patients. Under the best of circumstances what is there to be gained by the use of French brandy is preference to pure domestic spirit?

As a general rule the druggists throughout the State have shown a commendable desire to conform to the requirements of the laws relative to the sale of drugs, and the result has been a gradual but decided improvement in the actual quality of drugs as sold by them throughout the State.

The following list comprises the articles with reference to which notices were issued to retail druggists, informing them of the fact of adulteration. A list of cities and towns to which such notices were sent is also appended : —

Articles adulterated, on account of which notices were sent.

Olive oil,	6	White wine,	2
Oil of juniper,	6	Port wine,	4
Oil of cubebs,	2	Brandy,	1
Tincture of nux vomica,	11	Allspice,	2
Tincture of opium,	4	Iron and quinine, citrate,	1
Compound spirits of ether,	6	Saccharated carbonate of iron,	1
Spirits of nitrous ether,	4	Powdered mustard,	1
Potassium, iodide,	3	Powdered jalap,	1
Potassium, bitartrate,	2		
Saccharated pepsin,	3	Total,	69
Red wine,	9		

Places to which notices were sent.

Beverly,	3	Maynard,	3
Boston,	15	Medford,	1
Brookline,	1	Milford,	2
Cambridge,	1	New Bedford,	2
Canton,	1	Orange,	1
Chelsea,	6	Somerville,	1
Clinton,	2	Springfield,	1
Dedham,	1	Taunton,	1
Fall River,	6	Watertown,	1
Franklin,	2	Westborough,	1
Grafton,	1	Westfield,	2
Holyoke,	6	West Gardner,	1
Hyde Park,	1	West Medway,	1
Leominster,	2		
Lowell,	3	Total,	69

Prosecutions.

The whole number of prosecutions conducted during the year ending Sept. 30, 1887, was as follows: —

For sale of adulterated milk in Chelsea,	6 cases.
" " " in Boston,	4 "
" " " in Somerville,	1 case.
" " " in Cambridge,	1 "
" " " in Lynn,	1 "
" " " in Malden,	1 "
" " " in Newburyport,	1 "
" " " in Concord,	2 cases.
" " " in Northborough,	2 "
" " " in Hardwick,	2 "
" " " in West Berlin,	2 "
" " " in Millis,	2 "
" " " in Medford,	1 case.
" " " in Tyngsborough,	1 "
" " " in Stow,	1 "
" " " in Sudbury,	1 "
" " " in Beverly,	1 "
" " " in Westport,	1 "
" " " in Sherborn,	1 "
" " " in Norfolk,	1 "
" " " in Medway,	1 "
Total,	34 cases.

For sale of adulterated butter in Worcester,	4 cases.
" " " in Springfield,	4 "
" " " in Lawrence,	3 "
" " " in Lynn,	3 "
" " " in Lowell,	2 "
" " " in Holyoke,	2 "
" " " in Marlborough,	1 case.
Total,	19 cases.

For sale of adulterated honey in Medford,	1 case.
" " cream of tartar in Boston,	1 "
" " coffee in Boston,	1 "
" " cinnamon in Fitchburg,	1 "
" " allspice in Fitchburg,	1 "
" " molasses in Boston,	6 cases.

Summary.

Milk and milk products,	53 cases.
Other kinds of food,	11 "
Total,	64 cases.

Nearly all the foregoing complaints resulted in the conviction of the parties.

There were also seven other cases not included in the foregoing summary in which the evidence of guilt was sufficiently clear, but warrants were not obtained, either in consequence of inability to find the offenders or for other reasons of similar nature.

Expenses of Food and Drug Inspection from Oct. 1, 1886, to Sept. 30, 1887, under the Provisions of Chapters 263 of the Acts of 1882, and 289 of the Acts of 1884, relative to Food and Drug Inspection.

	Milk and Milk Products.	*Other Articles of Food and Drugs.*
Salary of Dr. Harrington,	$800 00	–
" of Prof. Goessmann,	500 00	–
" of Dr. E. S. Wood,	750 00	$750 00
" of Dr. B. F. Davenport,	750 00	750 00
" of J. H. Terry,	640 00	426 66
" of J. F. McCaffrey,	640 00	426 66
" of assistant analyst,	400 00	–
Legal services,	37 00	75 00
Special analyses,	5 00	35 00
Travelling expenses and purchase of samples,	1,032 71	688 47
Printing,	3 22	2 16
Packing boxes, bottles, materials for examination and incidentals,	21 74	70 00
	$5,579 67	$3,223 95
		5,579 67
Total,		$8,803 62

SAM'L W. ABBOTT,
Secretary.

REPORT OF THE ANALYST OF FOOD.

PROFESSOR EDWARD S. WOOD, M. D.

REPORT OF THE ANALYSTS OF FOOD.

PROFESSOR WOOD'S REPORT.

BOSTON, Oct 1, 1887.

Dr. S. W. ABBOTT, *Secretary State Board of Health.*

DEAR SIR : — I have the honor to submit my report on the Analysis of Foods for the year ending Sept. 30, 1887. I received 1,676 samples, of which 1,178 proved to be of good standard quality and 498 adulterated. Most of the adulterations detected were of the class known as merely fraudulent; those which may be classed as deleterious as well as fraudulent were tin salts in molasses, copper in vegetables, alum in baking powders, and nitrobenzol in extract of almonds. The percentage of adulterated samples, 29.71, is the lowest yet recorded for any year.

The samples received and examined and the results of examination are as follows : —

Vinegar. — I received 212 samples, which, with few exceptions, were sold as cider vinegar, the exceptions being uncolored "white-wine" vinegar. Eighty-three of these specimens conformed to the statute, which provides that there shall be not less than two per cent. of residue and four and a half of acetic acid. The remaining 129 samples were deficient either in acidity or residue or both.

Samples above Standard.

INSPECTOR'S NUMBER.	Acidity.	Residue.	INSPECTOR'S NUMBER.	Acidity.	Residue.
2514, ...	6.60	2.92	4535, ...	6.50	4.12
4527,*	6.52	–	4717, ...	6.04	4.62

* "White-wine" vinegar; uncolored.

Samples above Standard — Continued.

Inspector's Number.	Acidity.	Residue.	Inspector's Number.	Acidity.	Residue.
4171, ...	5 86	4.24	4543, ...	4.94	2.42
2927, ...	5.64	2.04	6089, ...	4.94	2.12
4502, ...	5.52	3.24	2332, ...	4.92	2.46
6069, ...	5.29	2.00	6905, ...	4.92	2.57
4007, ...	5.28	2.10	2394, ...	4.90	3.05
4363,*	5.28	-	4725, ...	4.90	3.36
4001, ...	4.80	2.42	5848, ...	4.90	3.00
5680, ...	4.80	2.00	7327, ...	4.89	2.94
6907,*	4.80	-	4003, ...	4.67	3.08
6153, ...	4.76	2.74	4019, ...	4.66	2.00
2643, ...	4.74	4.50	7323, ...	4.65	2.28
4629, ...	4.70	4 03	4361, ...	4.64	2.25
2593, ...	4.68	4 70	4397, ...	4.64	2.56
4925, ...	4.68	3.62	4729, ...	4.64	2.12
6913, ...	4.68	2.12	7495, ...	4.64	2.90
7511, ...	4.68	3.30	6657, ...	4.62	3.27
4365,*	5.24	-	6871, ...	4.62	2.78
4401, ...	5.20	2.62	6915, ...	4 62	3.54
6659, ...	5.16	2.37	3510, ...	4.61	2.12
4715, ...	5.16	3 44	6083,*	4.61	-
6071, ...	5.16	2.15	4403, ...	4.60	4.12
5858, ...	5.10	2.60	6691, ...	4.60	2.52
2521, ...	5.09	2.65	7505, ...	4.60	4.30
4537, ...	5.04	2.40	2523, ...	4.58	2.91
6899, ...	5.02	2.12	2577, ...	4.58	3 45
6145,*	5.02	-	2517, ...	4.56	4.94
4986, ...	5.00	2.00	4344, ...	4.56	2.00
2515, ...	4.98	2.14	4549, ...	4.56	2.58
7595, ...	4.96	4.50	6087, ...	4.56	2.05
7587, ...	4 96	4.00	6671, ...	4 56	4.09
2693, ...	4.96	3 26	6865, ...	4.56	2.28
4590, ...	4.95	3.32	6897, ...	4.56	2.38

* "White-wine" vinegar; uncolored.

Samples above Standard — Concluded.

Inspector's Number.	Acidity.	Residue.	Inspector's Number.	Acidity.	Residue.
4533, ...	4.88	5.11	2480, ...	4.52	2.08
4627, ...	4.88	2.88	4021, ...	4.52	2.60
6911, ...	4.86	2.07	4727, ...	4.52	2.35
6079,*	4.85	–	2493, ...	4.50	4.45
6169, ...	4.84	3.74	4531, ...	4.50	2.04
7591, ...	4.84	4.20	4721, ...	4.50	3.04
2569, ...	4.82	2.40	6173, ...	4.49	2.52
2871, ...	4.82	2.38			

* "White-wine" vinegar; uncolored.

Samples below Standard.

Inspector's Number.	Acidity.	Residue.	Inspector's Number.	Acidity.	Residue.
6693, ...	6.36	0.34	6177, ...	4.09	–
2575, ...	5.60	0.96	2869, ...	4.08	3.38
4163, ...	5.46	1.81	2591, ...	4.06	2.30
2865, ...	5.38	1.27	4723, ...	4.00	–
4031, ...	5.38	1.24	4662, ...	5.04	1.83
4009, ...	5.34	1.69	2923, ...	5.04	1.82
4165, ...	5.22	0.25	2519, ...	5.04	0.81
4545, ...	5.20	1.56	7223, ...	5.04	0.30
6621, ...	5.09	0.91	4635, ...	5.00	0.42
4713, ...	5.06	0.24	4547, ...	5.00	0.30
2583, ...	5.05	0.70	6869, ...	4.98	0.24
6081, ...	4.18	–	2639, ...	4.94	0.47
4169, ...	4.16	–	2681, ...	4.94	0.31
6163, ...	4.15	–	6613, ...	4.92	0.97
2909, ...	4.10	2.25	2809, ...	4.82	0.45
4998, ...	4.10	–	4029, ...	4.81	1.58
6909, ...	4.10	–	2505, ...	4.73	1.44
7593, ...	4.10	–	4167, ...	4.72	1.88

Samples below Standard — Continued.

Inspector's Number.	Acidity.	Residue.	Inspector's Number.	Acidity.	Residue.
2683, ...	4.70	0.40	2637, ...	3.54	0.38
4623, ...	4.60	1.40	6073, ...	4.46	-
2867, ...	4.56	1.88	4625, ...	4.44	2.23
6147, ...	4.56	0.73	5676, ...	4 44	-
7695, ...	4.56	0.80	6085, ...	4.44	-
2689, ...	4.54	0.62	6611, ...	4.44	1.90
2701, ...	4.54	1.85	7325, ...	4.44	2.82
5233, ...	4.51	0.21	4719, ...	4.40	1.81
4367, ...	4.48	1.48	5738, ...	4.40	-
4529, ...	4.46	4.84	2687, ...	4.38	0.15
6151, ...	3.99	-	2801, ...	4.38	0.37
4173, ...	3.97	-	6609, ...	4.38	0.94
2781, ...	3.96	0.63	6677, ...	4.38	0.26
4399, ...	3.96	-	6873, ...	4.38	2.60
4688, ...	3.96	2.25	6901, ...	4.38	-
4812, ...	3.96	0.47	2587, ...	4.37	1.59
2691, ...	3.89	0.47	6077, ...	4.37	-
3993, ...	3.88	-	6075, ...	4.34	-
2589, ...	3.84	2.53	6903, ...	4.34	-
4639, ...	3.84	-	2579, ...	4.33	2.15
2509, ...	3.81	1.82	2573, ...	4.32	2.12
6165, ...	3.80	-	6175, ...	4.32	2.42
7701, ...	3.78	-	7589, ...	4.32	-
2685, ...	3.77	0.12	7697, ...	4.32	-
6161, ...	3.76	-	6167, ...	4.31	-
3344, ...	3.74	-	7699, ...	3.54	-
2507, ...	3.72	1.72	2697, ...	3.50	0.38
4175, ...	3.72	-	4161, ...	3.50	-
4005, ...	3.70	-	6134, ...	3.50	-
4611, ...	3.64	-	4633, ...	3.48	-
4539, ...	3.60	-	4711, ...	3.48	-
7209, ...	3.57	4.61	2641, ...	3.41	0.46
3983, ...	3.56	-	2695, ...	3.38	0.35

Samples below Standard — Concluded.

Inspector's Number.	Acidity.	Residue.	Inspector's Number.	Acidity.	Residue.
2799, ...	3.36	0.20	4500, ...	2.58	3.16
3706, ...	3.35	–	7703, ...	2.44	–
2787, ...	3.34	0.43	6159, ...	4.22	–
6867, ...	3.30	3.12	6067, ...	4.22	–
2863, ...	3.26	0.37	7201, ...	4 21	2.25
4621, ...	3.18	–	6619, ...	4.20	0.23
4631, ...	3.18	–	6675, ...	4.20	3.02
4613, ...	3.08	–	2497, ...	4.18	3.10
2501, ...	3.01	2.68	4468, ...	2.34	1.80
2699, ...	3.00	4.50	3448, ...	2.30	–
2915, ...	3.00	2.13	2795, ...	2.04	1.29
4541, ...	2.96	–	3708, ...	2.04	–
7705, ...	2.96	–	4637, ...	1.96	–
7233, ...	2.94	2.66			

Butter. — Fifty-eight samples of butter were received and examined; 45 were genuine and 13 adulterated. Several which were passed as genuine were really oleomargarine, but were wrapped in paper so marked. In the examination of all these samples the method of Reichert has been followed. The following table shows the amount of decinormal sodic hydrate solution required for 2.50 grams of pure fat in those samples which proved to be adulterated. As a genuine butter-fat yields an amount of volatile fatty acids from 2.50 grams which will require for neutralization *at least* 12 cubic centimeters of the sodic hydrate solution, while the same weight of fat of oleomargarine will yield an amount which will require only about three cubic centimeters, it is plain that most of the following samples are mixtures containing greater or less amounts of pure butter.

Inspector's Number.	Number of C. C.'s of Decinormal Sodic Hydrate for Sol. Fat Acids from 2.50 Gram.	Inspector's Number.	Number of C. C.'s of Decinormal Sodic Hydrate for Sol. Fat Acids from 2.50 Gram.
1318, ...	10.60	2474, ...	3.00
1512, ...	9.90	3191, ...	9.00
1624, ...	10.20	3195, ...	9.80
1696, ...	9.30	3674, ...	2.80
1754, ...	7.10	A 1, ...	9.40
2026, ...	11.50	A 2, ...	11.10
2354, ...	11.70		

Cheese. — Eight samples; all genuine.

Lard. — Nineteen samples of lard include twelve which were adulterated with tallow. The following are the numbers and brands of the adulterated samples: —

4993. Armour & Co., Chicago.
4139. Armour & Co., Chicago.
4963. N. K. Fairbanks.
4973. N. K. Fairbanks.
3981. N. K. Fairbanks.
6501. Pure Leaf Lard.
5541. Hammond & Co., Detroit.
4889. Armour Packing Company, Kansas City.
3855, 4497, 6189, 8243. No brand.

Olive Oil. — Seventeen samples; six genuine and eleven spurious. The latter were confined to five brands, as follows: — Guillaume, Bordeaux; A. Seguin, Nice; E. Loubon, Nice; Ducro & Cie, Aix; Huile de Salade, Providence, R. I.

It is but fair to say that the inspectors avoid buying those brands which they know to be genuine, so that the proportion of two adulterated to one genuine sample bought does not hold good in the market at large.

Canned Vegetables. — Thirty-two samples of French vegetables were examined with special reference to the

presence of copper. This impurity was detected in 22 cases. The following table is self-explanatory : —

Inspector's Number.	Nature of Sample.	Copper found.	BRAND.
1629, .	Pease, . . .	No.	August Gillet, Pois Moyens au Knevel.
1988, .	" . . .	Yes.	J. Fiton Ainé & Cie, Petits Pois Verts au Naturel.
2330, .	" . . .	"	Charpentier, Usine de Montrouge, Petits Pois Fins.
2426, .	" . . .	"	Victor Tertrais, Pois Moyens, Nantes.
2741, .	" . . .	"	Soule & Price, Bordeaux.
2845, .	String beans, .	"	Dandicolle & Gaudin, Bordeaux.
2847, .	Pease, . . .	"	" " "
2849, .	Brussels sprouts,	"	" " "
2851, .	Pease, . . .	No.	Boutier le Mans.
2853, .	" . . .	"	" " (second quality).
2855, .	" . . .	"	Lebreton & Bree, Paris.
2857, .	String beans, .	"	Marcelino, Paris.
2859, .	Beans, . . .	Yes.	A. Billet, Flageolets Fins.
2861, .	Pease, . . .	No.	Alphonse Pinard, Bordeaux.
3098, .	" . . .	"	Marcelino, Petits Pois, Paris.
3099, .	" . . .	"	Fontaine Frères, Petits Pois, Paris.
3103, .	" . . .	"	Victor Tertrais, Pois Moyens, Nantes.
3341, .	" . . .	Yes.	Alexandre Eyquem, Petits Pois Verts, Bordeaux.
3343, .	" . . .	"	Alexandre Eyquem, Petits Pois Verts, Bordeaux.
3425, .	" . . .	"	Barton Fils, Petits Pois, Paris.
3921, .	" . . .	"	Marcelino. Petits Pois Fins, Paris.
3923, .	" . . .	"	Alphonse Pinard, Petits Pois Verts, Bordeaux.
4665, .	" . . .	"	Lanau Francois & Co., Petits Pois, Bordeaux.
5225, .	" . . .	No.	Marcelino, Petits Pois Fins au Naturel, Paris.
5226, .	" . . .	Yes.	Rödel & Fils Frs., Petits Pois Extra Fins au Naturel.
6091, .	" . . .	"	Dandicolle & Gaudin, Bordeaux.
6093, .	String beans, .	"	" " "
6095, .	Beans, . . .	"	" " "
6097, .	Brussels sprouts,	"	" " "
6099, .	Pease, . . .	"	Fontaine Frères, Petits Pois Extra Fins.
6471, .	" . . .	"	Dandicolle & Gaudin.
6539, .	" . . .	"	" "

Cream of Tartar. — I received 201 samples of cream of tartar, 167 of which were genuine and 34 adulterated. The principal adulterants were alum, terra alba, corn starch, tartaric acid and acid phosphate; in many cases more than one of these substances were present in the same sample. Most of the adulterated samples were bought unmarked with the name of the wholesaler. Among the adulterated samples were the following brands: — Hope Mills, Providence, R. I., and Allyn, Blanchard & Co., Hartford.

Soda. — Of sixteen samples all but one (No. 8255) were genuine. This sample contained a large excess of sulphates.

Baking Powders. — Twenty-nine samples were examined for alum which was found to be present in twenty-one. The latter comprised the following brands: — Davis, Springfield, Hygienic, Brooks & McGeorge, Aunt Sally, London, Capitol (purports to be made with cream of tartar), Old Colony, Holyoke, Dry Yeast, Higgins, White Star, International, Kenton, Sovereign.

Honey. — Thirty-five samples were received and nineteen were found to consist chiefly of glucose syrup. Nine of the latter bore no label; the others were marked as follows: —

1150. W. J. Lamb.
1352. A. J. Raymond, Pure White Clover Honey.
2124. Pure White Clover Honey. H. D. Gloyd, Medford.
2148. Dillon Bros., Medford. White Clover Honey.
2484. Pure White Clover Honey, A. J. Raymond, Boston.
2558. Pure Strained Honey.
2717. J. H. Dodge.
2739. A. J. Raymond, Pure White Clover Honey.
5772. J. Aborn & Co., Boston & Hyde Park.
8159. Dillon Bros., Medford.

Molasses. — Eighty-four samples were examined for corn-glucose and salts of tin; twenty-five were found to be adulterated with one or the other, or both, of these substances. The adulterated samples were as follows: —

Inspector's Number.	Corn Glucose.	Tin.	Inspector's Number.	Corn Glucose.	Tin.
2472, ...	No.	Yes.	5775, ...	No.	Yes.
2512, ...	"	"	6022, ...	Yes.	No.
2810, ...	Yes.	"	6101, ...	"	"
2812, ...	"	"	6143, ...	"	"
2814, ...	"	"	6187, ...	"	"
5223, ...	No.	"	6207, ...	"	"
5236, ...	Yes.	No.	6237, ...	"	"
5263, ...	No.	Yes.	6321, ...	"	"
5501, ...	"	"	6381, ...	"	"
5503, ...	Yes.	"	6493, ...	"	"
5518, ...	"	No.	6497, ...	"	"
5647, ...	No.	Yes.	7445, ...	"	"
5697, ...	Yes.	No.			

Molasses Candy. — Twenty-three samples were examined with special reference to tin, which was found in three samples (Nos. 3337, 4061 and 4261).

Maple Sugar and Syrup. — Fourteen samples of the former and nine of the latter were received and examined. Five of the former and three of the latter were found to be adulterated with glucose. One of the samples of maple sugar was composed almost entirely of "molasses sugar."

Sugar. — Ten specimens of powdered and granulated sugar were examined and found to be pure.

Candy. — Twenty-four samples of colored candies were examined for poisonous colors; all were found to be free from anything deleterious.

Ginger Ale. — Three samples were submitted for examination for metallic contaminations which were found not to exist.

Coffee. — Of eleven samples received, two were adulterated. No. 4114 contained burnt rye and chiccory; No. 4612 was chiefly burnt rye.

Chocolate. — Ten samples were received and found to be genuine.

Cocoa. — One sample (Epes') was found to be as represented — a mixture of cocoa, sugar and arrowroot.

Tea. — Twenty-eight samples; all genuine.

Isinglass. — Two samples examined were found to be adulterated with potato starch.

Black Pepper. — One hundred and forty-six samples; 93 genuine, 53 adulterated. The most common adulterants were ground cracker, corn, rice and buckwheat. Among the adulterated samples were the following brands: — Lester, Providence, R. I.; E. R. Durkee, New York; Springfield Coffee and Spice Company; Windsor Mills, N. Y.; I. W. Sprague, Providence, R. I.; Globe Mills; Allyn & Blanchard, Hartford; Haskell & Adams; J. E. Rounds & Co., Providence, R. I.; Union Spice Company; Colburn's.

White Pepper. — Seventy-one samples; 39 genuine, 32 adulterated. The adulterants used were the same as mentioned under black pepper, and the adulterated brands are included in the above list.

Mustard. — One hundred and twenty-two samples; 90 genuine, 32 adulterated. The adulterated samples included the following brands: — Colburn's; Ardenter; English; E. W. Ropes, New York; Hope Mills, Providence, R. I.; London; Judson, Parsons & Haskell, Albany; Golding & Co.; E. R. Durkee, New York; Colman's; Springfield Coffee and Spice Company; Boston Mills.

Cassia. — One hundred and twenty-three samples; 101 genuine, 22 adulterated. The following brands were found

among the adulterated samples: — Allyn & Blanchard, Hartford; E. W. Ropes, New York; Union Spice Company, New York; Brunswick Mills, New York; Springfield Coffee and Spice Company.

Ginger. — One hundred and thirty-four samples; 112 genuine, 22 adulterated. Rice, cracker, corn and turmeric were the most common adulterants.

Cayenne. — Twenty-seven samples; 19 genuine, 8 adulterated. The foreign substances were chiefly cracker, corn and ginger. The adulterated brands were — New England Coffee and Spice Mills; I. W. Sprague, Providence; Globe Mills; Tropical Mills.

Nutmeg. — Of five samples of ground nutmeg all were genuine, with one exception (1312), which was adulterated with cracker.

Cloves. — Sixty-five samples; 56 of good quality, 9 adulerated. Many of the samples were deficient in oil, but contained no foreign matter. A *small* percentage of stems has not been considered actual adulteration. Corn, cracker, allspice and clove stems were the foreign substances found.

Allspice. — Fifty-four samples; 48 genuine, 6 adulterated. The adulterants were cracker, buckwheat and dirt.

Mace. — Twenty-two samples; 14 genuine, 8 adulterated. The adulterants were wheat, ginger and wild mace.

Macaroni. — Four samples of yellow macaroni were examined for poisonous colors, which proved to be absent.

Extract of Almonds. — Nine samples were received; two were found to contain a poisonous substance — nitrobenzol — which was added to give the almond flavor.

Orange Cider. — One sample of this beverage, which purports to be made from Florida oranges and is advertised as

"nature's most healthful beverage," proved to be an artificial compound containing about 15 per cent. of sugar, 0.96 per cent. of tartaric acid, and coloring and flavoring substances.

Miscellaneous. — I received also the following samples, all of which proved to be of good quality: — Milk sugar, 1; Sage, 5; Savory, 2; Marjoram, 3; Thyme, 3; Celery salt, 6; Horseradish, 4; Corn starch, 3; Currie powder, 2; Gelatine, 5; Pickles, 1; Yeast, 3; Bread, 1; Condensed milk, 3; Raspberry jam, 3; Cider jelly, 2.

Summary.

Nature of Samples.	Number of Genuine Samples.	Number of Adulterated Samples.	Total Number of Samples.
Vinegar,	83	129	212
Butter,	45	13	58
Cheese,	8	–	8
Lard,	7	12	19
Olive oil,	6	11	17
Canned vegetables,	10	22	32
Cream of tartar,	167	34	201
Soda,	15	1	16
Baking powders,	8	21	29
Honey,	16	19	35
Molasses,	59	25	84
Molasses candy,	20	3	23
Maple sugar,	9	5	14
Maple syrup,	6	3	9
Sugar,	10	–	10
Candy,	24	–	24
Ginger ale,	3	–	3
Coffee,	9	2	11
Chocolate,	10	–	10
Cocoa,	1	–	1
Tea,	28	–	28
Isinglass,	–	2	2
Black pepper,	93	53	146

Summary — Concluded.

NATURE OF SAMPLES.	Number of Genuine Samples.	Number of Adulterated Samples.	Total Number of Samples.
White pepper,	39	32	71
Mustard,	90	32	122
Cassia,	101	22	123
Ginger,	112	22	134
Cayenne,	19	8	27
Nutmeg,	4	1	5
Cloves,	56	9	65
Allspice,	48	6	54
Mace,	14	8	22
Macaroni,	4	–	4
Extract of almonds,	7	2	9
Orange cider,	–	1	1
Milk sugar,	1	–	1
Sage,	5	–	5
Savory,	2	–	2
Marjoram,	3	–	3
Thyme,	3	–	3
Celery salt,	6	–	6
Horseradish,	4	–	4
Corn starch,	3	–	3
Currie powder,	2	–	2
Gelatine,	5	–	5
Pickles,	1	–	1
Yeast,	3	–	3
Bread,	1	–	1
Condensed milk,	3	–	3
Raspberry jam,	3	–	3
Cider jelly,	2	–	2
Total,	1,178	498	1,676

Respectfully submitted,

EDWARD S. WOOD, M.D.

DR. DAVENPORT'S REPORT.

FOOD.

Boston, Oct. 1, 1887.

S. W. Abbott, M. D., *Secretary State Board of Health.*

Sir: — I have the following report to make upon the 113 samples of food which were submitted to me for examination during the past twelve months, and of which 28, or 24.8 per cent., were found not to be of the good standard quality for which they were purchased. This is a decided gain over the 33.3 per cent. found in last year's samples.

Among the samples were 48 which were marked as butter and seven as oleomargarine. Of these, 14 so called butters proved to be oleomargarine, and one of the oleomargarines proved to be a true butter.

The method employed for the determination has been the Reichert-Meissel's distillation process described in my last year's report, which, however, has been improved in the following particulars. As recommended by Dr. R. Wollny in the "Milch-Zeitung" during this year, and in part by the Fourth Annual Convention of the Association of Official Agricultural Chemists held at Washington, D. C., in August, 1887, the 10 c.c. of alcoholic solution of caustic potassa has been replaced by 4 c.c. of a 50 per cent. aqueous solution of caustic soda. This and about 4 c.c. of a 90 per cent. alcohol are to be separately measured off and added to the five grams of butter fat for its saponification. In this manner any disturbance with the phenol phthalein used as the indicator in the final titration, due to the presence of

carbonates in the potassa when that is used, is avoided, as well as the gradual and ever-varying change which takes place in the alcoholic potassa solution. With the improved method the blank correction remains constant for the same alcohol and soda solutions. As recommended by E. Dannerberg, a few small tufts of long fibered asbestos are an improvement even upon pieces of pumice weighed down with platinum or lead for the prevention of the violent thumping which is so very liable to occur during the distillation of the volatile acids. This method of analysis seems to furnish the most ready certain method for the determination of any practical amount of foreign fatty matter. Yet, if while melting my sample of butter in the beaker upon the water bath to allow the water, the salt and curd to settle out to the bottom of the fat I notice that there is a markedly less amount of curd than I have learned from experience to expect in a pure butter, I then begin to very strongly suspect that I am dealing with a sample of oleomargarine. If when making my distillation I obtain any solid deposit within my condenser tube, then I know for a surety that I am dealing with an oleomargarine, for never once have I found that I had been deceived by these indications when I came to the final titration of the distillate. Since the national oleomargarine act has gone into operation I have no longer met with the mixed goods I previously did. Now all samples prove to be either whole butter or else straight oleomargarine.

Of cheese 13 samples were examined for the presence of foreign fats. The fat was extracted by macerating the cheese in petroleum naphtha of the quality of the benzine of the United States Pharmacopœia. The fat left after the evaporation of the naphtha solution was treated exactly as in a butter examination for foreign fat. In no case was any foreign fat found. In the cases of cheese poisoning which are occasionally reported the cause is doubtless the presence of a fermentation product known as a ptomaine. The one found in the case of such cheese has been named by Prof. V. Vaughan of Ann Arbor, Mich., tyrotoxicon.

The very general use of annotto or other coloring-matter in butter or cheese is to be condemned as having but one

fraudulent purpose, that of making them each to appear to be of a better or finer quality than they really are. In the case of butter it is to make the inferior winter, or dry feed butter, to appear to be June or grass butter. In the case of cheese it is to make skim or poor milk quality cheese to appear to be as of whole or rich milk. A further objection to the use of an annotto coloring is what is mentioned upon the subject in my report upon milk, yet I understand that some of the oleo manufacturers do not make any use of the very objectionable paste form of the dye-stuff, but prepare their coloring directly from the dried seeds themselves, by boiling them in cotton-seed or a similar oil. When the farmers and dairymen no longer use coloring to falsify the appearance of their own product they can more becomingly demand that the oleomargarine manufacturer be no longer allowed to use it in his product. In the cause of simple justice neither of them should be allowed to use it at all. The presence of annotto coloring in either butter or cheese is easily detected by a method similar to that used in the case of milk, for if either of them when thus colored be shaken up with water which has been rendered but very slightly alkaline and warmed enough to melt them, or else their fat be first dissolved in some ether or naphtha, the coloring will be extracted by the water. The coloring can then be extracted from this water by the use of paper, and then tested exactly as in the like case with milk.

Of condensed milks six samples were examined, which were all of Swiss origin. These all, as is the usual thing in this article, were somewhat deficient in the proportion of fat present, as compared with good natural milk, and somewhat excessive in the amount of sugar contained, although milk sugar alone rather than any foreign cane sugar seemed to be present in these samples. There appears to be some great practical difficulty in condensing into a uniform mass a milk having a good natural amount of fat present; a milk of a natural or artificial skim-milk quality is much more easily worked in the vacuum pan.

Of molasses 21 samples were examined for the presence of glucose syrup and of tin salts. Of these six samples

were found to contain extra glucose in considerable amounts, that is from 20 to 30 per cent., or even more. No tin salts were found. All of them were probably of West Indian origin, where tin solutions are not generally used in the bleaching of the sugar crystals as is the custom with the planters in Louisiana with their centrifugal sugars. That the New Orleans "Picayune" should commonly include tin crystals in advertised lists of plantation chemicals, is strong evidence of how general their use is there. In all known samples of straight New Orleans molasses which I have hitherto examined for it, I have found tin to be present; therefore some knowledge of the origin and mode of manufacture of a molasses is necessary for the formation of any just opinion as to the probable cause for any tin salts which may be found to be present in it.

Of cider vinegar nine samples were examined, of which seven were found not to be of good, standard quality, being deficient either in acid strength or quality as the product of pure apple juice. The question of quality was determined by the methods of examination mentioned in my last report. For commercial purposes the acid strength is easily determined by the following method. The apparatus consists simply of a glass tube, closed at one end, of which the bore is two to three eighths of an inch. At the height of 6 c.c. above the closed end of the tube the mark of 0 % is placed. Above this each c.c. and subdivision of tenths is marked up to 10 c.c., but always with the sign % instead of c.c. For use the tube is filled with the vinegar to be tested for its strength up to the 0 % mark. After a drop or two of a tincture of phenolphthalein has been added, a normal solution of caustic alkali is cautiously added, with repeated inversions and gentle shaking up of the contents of the tube while firmly closed by the thumb placed over its mouth, until at last a single drop of the alkali causes a permanent pink color to appear in the mixture. The height of the fluid then within the tube, when read off upon its graduation, gives the percentage of acidity of that sample of vinegar. The tube when emptied and rinsed out once with the new vinegar to be

tested is ready for use. The cost of such an acetometer is less than a dollar. An ounce or two of a tincture of phenolphthalein and a pint or so of the normal volumetric solution of soda, which is described on page 399 of the last edition of the United States Pharmacopœia, can be obtained for a small sum from any competent apothecary in any town of the State, and are the only test solutions needed. One pint of the soda would test about 100 vinegars of ordinary cider vinegar strength.

Of honey six samples were examined and all found to be the true product of the honey-bee. The adulteration of honey, especially of that sold as strained or clarified honey, is now exceedingly common. It is said that modern chemistry has devised a method whereby certain organic acids acting upon some of the starches, such as maize, but not on potato, will produce a syrup, which in a proper concentration, and allowed to undergo a ripening process by simple aging for two or three weeks, will then so exactly resemble true honey that not only it cannot be distinguished from it either in taste or appearance, but even cannot be detected through the use of polarized light, or the other ordinary means used by professional chemists for discriminating between the different kinds of sugars. Yet fortunately there is a very simple and reliable method for detecting the most common of all forms of adulteration in honey, that with common glucose syrup. The admixture of any profitable amount of this glucose to a honey will cause it to leave upon ignition an ash having a neutral reaction upon test paper. The ash of true honey is always strongly alkaline, and contains from one to three one-hundredths of one per cent. of phosphoric acid. In this last particular all kinds of artificial honey differ widely from it, running much either above or below it.

One proprietary food, a custard powder for making up custards without the use of eggs, was submitted for examination for the presence of any injurious yellow coloring-matter. The color was found to be due to the presence of a small fraction of one per cent. of true saffron. The most of the powder was simply an arrowroot starch flavored with lemon.

Two samples of yellow cakes were examined for the presence of chrome or any other injurious yellow coloring-matter present as a substitute for eggs, but none such was found to be present in either case.

Respectfully submitted,

BENNETT F. DAVENPORT.

REPORTS OF THE ANALYSTS OF MILK.

DR. HARRINGTON'S REPORT.

BOSTON, Oct. 1, 1887.

DR. S. W. ABBOTT, *Secretary of the State Board of Health.*

DEAR SIR: — I have the honor to submit the following report on the examination of Milk for the year ending Sept. 30, 1887.

During the year I received 1,800 samples, which were obtained from the milk supplies of twenty cities and thirty-four towns, from suspected producers and directly from the cow (samples of known purity).

Of the whole number 1,045, or 59.06 per cent., proved to be above, and 755, or 41.94 per cent., below the statute standard.

Twenty cities furnished 1,065 samples, of which 580, or 54.46 per cent., were above, and 485, or 45.54 per cent., below the standard. The percentage of adulterated samples in this group ranges from 7.14 (New Bedford) to 72.41 (Somerville), as follows: —

1. New Bedford,	7.14	11. { Newburyport,	41.67
2. Gloucester,	8.33	11. { Taunton,	41.67
3. Brockton,	9.09	13. Waltham,	42.86
4. Fitchburg,	18.37	14. Chelsea,	51.67
5. Salem,	25.00	15. Boston,	55.38
6. Lawrence,	29.31	16. Cambridge,	56.40
7. Worcester,	30.49	17. Malden,	58.14
8. Newton,	32.43	18. Lowell,	58.82
9. Haverhill,	36.73	19. Lynn,	63.64
10. Fall River,	37.93	20. Somerville,	72.41

Of the above 1,065 samples 72 were passed as good, without analysis; of the remainder,—

50	contained over 15 per cent. total solids.
90	" between 14 and 15 per cent. total solids.
329	" " 13 and 14 per cent. "
334	" " 12 and 13 per cent. "
138	" " 11 and 12 per cent. "
36	" " 10 and 11 per cent. "
8	" " 9 and 10 per cent. "
2	" " 8 and 9 per cent. "

And six were skimmed milks of good standard quality.

Thirty-four towns furnished 491 samples, of which 360, or 73.32 per cent., were above, and 131, or 26.68 per cent., below the statute standard. The percentage of samples below standard from each of the towns may be seen in the summary. Of these 491 samples 16 were passed as good on inspection; of the remainder,—

37	contained over 15 per cent. total solids.
62	" between 14 and 15 per cent. total solids.
193	" " 13 and 14 per cent. "
121	" " 12 and 13 per cent. "
39	" " 11 and 12 per cent. "
9	" " 10 and 11 per cent. "
3	" " 9 and 10 per cent. "
2	" less than 9 per cent. "

And nine were skimmed milks of good standard quality.

Suspected producers furnished 147 samples, of which 59, or 40.14 per cent., were above, and 88, or 59.86 per cent., below the statute standard. Of these samples,—

2	contained over 15 per cent. total solids.
8	" between 14 and 15 per cent. total solids.
48	" " 13 and 14 per cent. "
69	" " 12 and 13 per cent. "
11	" " 11 and 12 per cent. "
3	" " 10 and 11 per cent. "
1	" less than 9 per cent. "

Samples of known purity to the number of 97 were obtained from two farms,—6 from one and 91 from the other. Of these, 46, or 47.42 per cent., were above, and 51, or 52.58 per cent., below the standard.

2	contained	over 15 per cent. total solids.		
9	"	between	14 and 15 per cent.	total solids.
33	"	"	13 and 14 per cent.	"
35	"	"	12 and 13 per cent.	"
13	"	"	11 and 12 per cent.	"
4	"	"	10 and 11 per cent.	"
1	"	"	9 and 10 per cent.	"

Of the whole number of samples received 88 were passed without analysis. Of the remaining 1,712 specimens, —

91	contained	over 15 per cent. total solids.		
169	"	between	14 and 15 per cent.	total solids
603	"	"	13 and 14 per cent.	"
559	"	"	12 and 13 per cent.	"
206	"	"	11 and 12 per cent.	"
52	"	"	10 and 11 per cent.	"
12	"	"	9 and 10 per cent.	"
5	"	less than 9 per cent.		"

And 15 were skimmed milks of standard quality.

Suspected Producers.

Of the 147 samples from farmers the first 47 were from twenty-one different sources investigated by the inspectors of the Board. The remaining 100 were taken by myself from quart jars left at my door by a milk dealer, who is also a producer. Four samples were taken daily for twenty-five consecutive days. The investigation showed that 53 of the 100 were below the standard. The producer on being informed of the quality of his milk took immediate steps to ascertain the cause of the same. Samples of 91 separate milkings were taken personally by Mr. Charles P. Worcester at the farm, and by him were subjected to thorough analysis in my laboratory. The results of his analyses will be found under "Samples of Known Purity."

Of the above-mentioned 47 samples from twenty-one sources 12, or 25.53 per cent., were above, and 35, or 74.47 per cent., below the standard.

Inspector's Number.	Results of Analysis.			
	Fat.	Solids, not Fat.	Total Solids.	Water.
* 932,	2.97	8.96	11.93	88.07
934,	3.10	8.54	11.64	88.36
* 936,	4.31	9.03	13.34	86.66
938,	3.54	9.87	13.41	86.59
* 940,	3.65	9.10	12.75	87.25
942,	3.29	8.91	12.10	87.90
* 944,	3.41	9.47	12.88	87.12
946,	2.88	8.98	11.86	87.14
3617,	19.64	8.05	27.69	72.31
3619,	3.40	9.72	13.12	86.88
3621,	3.27	10.02	13.29	86.71
3623,	3.27	9.69	12.96	87.04
3625,	3.09	9.08	12.17	87.83
4907,	1.80	6.23	8.03	91.97
* 4909,	2.98	9.96	12.94	87.06
4911,	2.88	9.84	12.74	87.26
4913,	2.58	8.96	11.54	88.46
* 4915,	3.59	8.97	12.56	87.44
4917,	2.57	9.75	12.32	87.68
* 4919,	2.60	9.08	11.68	88.32
4921,	2.83	9.52	12.35	87.65
* 6283,	2.84	8.74	11.58	88.82
6285,	3.28	9.25	12.53	87.47
* 6287,	2.96	7.51	10.47	89.53
6289,	3.43	7.06	10.49	89.51
* 7781,	3.27	9.74	13.01	86.99
7783,	4.26	10.01	14.27	85.73
7785,	4.08	9.54	13.62	86.38
* 7787,	2.87	10.38	13.25	86.75
7789,	3.20	10.08	13.28	86.72
7791,	1.12	9.78	10.90	89.10
* 7793,	2.89	9.00	11.89	88.11
7795,	3.41	9.31	12.72	87.28
7797,	3.31	9.67	12.98	87.02
7799,	3.96	10.25	14.21	85.79
* 7801,	3.03	9.47	12.50	87.50
7803,	2.93	9.91	12.84	87.16
7805,	1.74	9.81	11.55	88.45
7807,	2.71	9.22	11.93	88.07
8043,	3.52	8.33	11.85	88.15
8045,	3.42	8.81	12.23	87.77
8047,	3.28	8.85	12.13	87.87
* 8049,	3.92	8.73	12.65	87.35
8051,	2.92	8.30	11.22	88.78
8053,	3.54	8.60	12.14	87.86
8055,	3.25	9.32	12.57	87.43
8057,	3.61	8.35	11.96	88.04

* Samples braced are from a common source.

The remaining 100 samples from one producer yielded the following figures :—

Date.	Results of Analysis.			
	Fat.	Solids, not Fat.	Total Solids.	Water.
Feb. 2,	–	–	13.49	86.51
	–	–	13.40	86.60
	–	–	13.26	86.74
	–	–	13.25	86.75
3,	–	–	13.23	86.77
	3.81	9.08	12.89	87.11
	2.75	9.75	12.50	87.50
	2.84	8.71	11.55	88.45
4,	3.23	9.07	12.30	87.70
	3.60	9.16	12.76	87.24
	3.20	9.07	12.27	87.73
	3.22	9.03	12.25	87.75
5,	2.86	9.15	12.01	87.99
	–	–	13.13	86.87
	2 90	9.52	12.42	87.58
	2.80	9.82	12.62	87.38
6,	–	–	12.72	87.28
	–	–	13.00	87.00
	–	–	12.63	87.37
		–	12.44	87.56
7,		–	13.11	86.89
	–	–	13.11	86.89
		–	13.16	86.84
		–	13.12	86.88
8,	–	–	13.04	86.96
	–	–	13.04	86.96
	3.01	9.26	12.27	87.73
	–	–	13.03	86.97
9,	–	–	13.09	86.91
		–	13.08	86.92
		–	12.94	87.06
	-	–	12.07	87.93
10,		–	13.19	86.81
		–	12.99	87.01
	–	–	13.31	86.69
	–	–	13.17	86.83
11,	3.78	9.02	12.80	87.20
	3.81	9.01	12.82	87.18
	–	–	13.53	86.47
	2.57	9.14	11.71	88.29
12,	2.95	9.42	12.37	87.63
	2.55	9.86	12.38	87.62
	2.99	9.62	12.61	87.39
	3.15	9.38	12.53	87.47
13,	–	–	13.28	86.72
	3.50	8.84	12.34	87.66
	–	–	13.36	86.64
	–	–	12.56	87.44
14,	–	–	13.43	86.57
	–	–	13.30	86.70
	3.34	9.40	12.74	87.26
	–	–	13.16	86.84

DATE.	Results of Analysis.			
	Fat.	Solids, not Fat.	Total Solids.	Water.
Feb. 15, ...	–	–	13.38	86.62
	–	–	13.29	86.71
	–	–	13.18	86.82
	–	–	13.21	86.79
16, ...	4.03	8.87	12.90	87.10
	3.85	9.02	12.87	87.13
	3.13	8.77	11.90	88.10
	3.93	8.92	12.85	87.15
17, ...	3.16	8.19	11.35	88.65
	3.79	8.36	12.15	87.85
	3.85	8.25	12.10	87.90
	–	–	13.27	86.73
18, ...	3.76	9.04	12.80	87.20
	4.11	9.04	13.15	86.85
	3.95	8.99	12.94	87.06
	3.27	9.26	12.53	87.47
19, ...	3.42	9.55	12.97	87.03
	3.68	9.37	13.05	86.95
	2.57	9.60	12.17	87.83
	3.54	9.35	12.89	87.11
20, ...	3.32	9.44	12.76	87.24
	3.29	9.38	12.67	87.33
	–	–	14 42	85.58
	3.19	9.58	12.77	87.23
21, ...	–	–	13.27	86.73
	1.96	10.15	12.11	87.89
	–	–	15.39	84.61
	2.50	9.92	12.42	87.58
22, ...	–	–	13.24	86.76
	3.28	9.27	12.55	87.45
	–	–	13.50	86.50
	–	–	13.33	86.67
23, ...	–	–	14.12	85.88
	–	–	14.63	85.37
	–	–	14.20	85.80
	–	–	13.67	86.33
24, ...	–	–	12.70	87.30
	–	–	12.63	87.37
	–	–	12.12	87.88
	–	–	14.68	85.32
25, ...	–	–	12.23	87.77
	–	–	12.31	87.69
	–	–	14.41	85.59
	–	–	12.28	87.72
26, ...	–	–	13.32	86.68
	–	–	12.70	87.30
	–	–	13.48	86.52
	–	–	13.58	86.42

Samples of Known Purity.

Six samples of known purity were submitted by the officers of the Board. The results obtained were as follows: —

Inspector's Number.	Fat.	Solids, not Fat.	Total Solids.	Water.
3874, ...	4.49	9.72	14.21	85.79
3876, ...	3.58	8.78	12 36	87.64
3878, ...	1.53	10.75	12.28	87.72
3880, ...	2.60	9.21	11.81	88.19
3882, ...	5.79	8.96	14.75	85.25
3884, ...	3.84	9.18	13.02	86.98

The next 91 analyses have been already referred to under "Suspected Producers." Each sample was taken by Mr. Charles P. Worcester personally, and carefully analyzed. I am indebted to him for the following figures: —

Number of Cow.	Age in Years.	Time since Calving (Months).	Breed.	Time of Milking (A. M. or P. M.).	Amount of Milk yielded. (pounds).	Results of Analysis. Sp. Gr. at 15° C.	Fat.	Solids, not Fat.	Sugar.	Albuminoids.	Ash.	Total Solids.	Water.
1, . . .	7	6	Holstein,	A. M.	11	1.0344	3.03	8.71	4.50	3.56	.65	11.74	88.26
2, . . .	7	1	"	"	16	1.0304	2.93	8.50	4.25	3.62	.63	11.43	88.57
3, . . .	7	15	"	"	7	1.0338	2.69	8.91	4.55	3.78	.58	11.60	88.40
5, . . .	7	1	"	"	18	1.0322	3.05	8.70	4.55	3.52	.63	11.75	88.25
* . . .	–	–	"	P. M.	16	1.0352	2.67	7.62	–	–	.65	10.29	89.71
6, . . .	7	3	"	A. M.	16	1.0336	2.03	8.64	4.70	3.29	.65	10.67	89.33
* . . .	–	–	"	P. M.	15	1.0304	2.47	8.17	–	–	.61	10.64	89.36
8, . . .	7	5	"	A. M.	8	1.0315	3.06	8.16	4.00	3.52	.64	11.22	88.78
* . . .	–	–	"	P. M.	8	1.0294	2.47	7.50	–	–	.56	9.97	90.03
9, . . .	5	7	"	A. M.	5	1.0358	2.62	9.80	4.60	4.57	.63	12.42	87.58
* . . .	–	–	"	P. M.	6	1.0324	3.00	9.18	–	–	.66	12 18	87.82
11, . . .	5	5	"	A. M.	9	1.0347	4.12	9.81	5.00	4.14	.66	13.93	86.07
* . . .	–	–	"	P. M.	9	1.0350	3.42	9.37	–	–	.59	12.79	87.21
12, . . .	5	3	"	A. M.	13	1.0347	3.28	9.29	5.05	3.56	.68	12.57	87.43
* . . .	–	–	"	P. M.	13	1.0314	2.14	9.93	–	–	.63	11.07	88.93
13, . . .	5	6	"	A. M.	9	1.0368	2.83	10.36	5.15	4.59	.62	13.19	86.81
* . . .	–	–	"	P. M.	10	1.0324	2.59	9.70	–	–	.64	12.29	87.71
16, . . .	3	1	"	A. M.	14	1.0378	2.98	10.50	4.75	5.04	.71	13.48	86.52
* . . .	–	–	"	P. M.	13	1.0309	2.84	9.39	–	–	.67	12.23	87.77
17, . . .	2	3	"	A. M.	10	1.0338	3.87	7.62	5.25	1.71	.65	11.49	88.51
* . . .	–	–	"	P. M.	9	1.0323	3.75	9.05	–	–	.66	12.80	87.20
18, . . .	2	2	"	A. M.	9	1.0317	2.80	9.05	5.00	3.46	.59	11.85	88.15
* . . .	–	–	"	P. M.	10	1.0333	3.28	8.90	–	–	.60	12.18	87.82
19, . . .	2	2	"	A. M.	6	1.0349	3.28	9.73	5.00	4.12	.61	13.01	86.99
* . . .	–	–	"	P. M.	6	1.0350	2.94	9.55	–	–	.61	12.49	87.51

20, . . .	2	2	"	A. M.	8	1.0343	2.90	9.72	5.10	3.96	.66	12.62	87.38
21, . . .	2	2	"	"	8	1.0349	4.35	9.69	5.50	3.52	.67	14.04	85.96
* . . .	–	–	"	P. M.	6	1.0338	3.41	9.63	–	–	.65	13.04	86.96
26, . . .	–	–	"	A. M.	10	1.0327	3.99	9 34	4.95	3.61	.67	13.33	86.67
27, . . .	6	8	Native,	"	10	1.0328	3.81	9.35	4.75	3.95	.66	13.16	86.84
32, . . .	–	–	"	"	10	1.0352	2.41	9.42	5.00	3.77	.66	11.83	88.17
33, . . .	–	–	"	"	7	1.0402	3.35	11.97	4.25	6.94	.78	15.32	84.68
34, . . .	–	–	"	"	7	1.0330	2.42	8.88	4.50	3.79	.59	11.30	88.70
35, . . .	–	–	"	"	6	1.0341	4.00	10.34	4.50	5.16	67	14.34	85.66
36, . . .	–	–	"	"	7	1.0319	3.59	9.39	5.05	3.76	.59	12.98	87.02
38, . . .	–	–	"	P. M.	8	1.0338	4.39	9.42	–	–	.65	13.81	86.19
40, . . .	–	–	"	A. M.	–	1.0350	4.11	9.53	5 00	3.90	.63	13.64	86.36
51, . . .	10	1	"	"	9	1.0349	2.91	10.01	3.40	5.93	.68	12.92	87.08
52, . . .	8	7	"	"	10	1.0365	3.56	9.24	5.10	3.49	.65	12.80	87.20
* . . .	–	–	"	P. M.	9	1.0327	3.22	9.23	–	–	.59	12.45	87.55
53, . . .	8	7	"	A. M.	11	1.0344	3.25	9.53	4.60	4.29	.63	12.78	87.22
54, . . .	6	8	"	"	15	1.0327	3.52	9.19	5.00	3.53	.66	12.71	87.29
55, . . .	6	8	"	"	8	1.0325	3.82	9.83	5.10	4.02	.71	13.65	86.35
56, . . .	7	8	"	"	12	1.0336	3.76	9.42	5.00	3.71	.70	13.18	86.82
* . . .	–	–	"	–	10	1.0336	4.37	10.13	4.50	5.03	.60	14.50	85.50
* . . .	–	–	"	P. M.	9	1.0330	2.99	8.61	–	–	.75	11.60	88.40
57, . . .	8	5	"	A. M.	10	1.0347	3.73	9.58	4.25	4.74	.60	13.31	86.69
58, . . .	7	8	"	"	9	1.0349	4.17	9.68	4.75	4.28	.65	13.85	86.15
59, . . .	6	2	"	"	12	1.0338	3.47	9.20	5.10	3.47	.63	12.67	87.33
60, . . .	6	2	"	"	8	1.0341	4.50	10.14	4.95	4.62	.57	14.64	85.36
63, . . .	5	1	"	"	11	1.0330	3.81	9.71	4.75	4.36	.61	13.52	86.48
64, . . .	6	2	"	"	9	1.0327	3.33	9.08	4.45	4.00	.62	12.41	87.59
* . . .	–	–	"	P. M.	11	1.0315	4.21	8.66	–	–	.60	12.87	87.13
65, . . .	4	5	"	A. M.	12	1.0371	3.38	9.60	5.05	3.93	.61	12.98	87.02
* . . .	–	–	"	P. M.	12	1.0314	3.17	9.29	–	–	.65	12.46	87.54

* The same a few days later.

Number of Cow.	Age in Years.	Time since Calving (Months).	Breed.	Time of Milking (A. M. or P. M.).	Amount of Milk yielded (pounds).	Results of Analysis.							
						Sp. Gr. at 15° C.	Fat.	Solids, not Fat.	Sugar.	Albuminoids.	Ash.	Total Solids.	Water.
66, . . .	5	5	Native,	A. M.	9	1.0335	3.46	9.54	4.90	3.99	.64	13.00	87.00
* . . .	–	–	"	P. M.	10	1.0338	4.07	9.81	–	–	.64	13.88	86.12
67, . . .	6	1	"	A. M.	3	1.0330	3.44	9.99	4.50	4.90	.60	13.43	86.57
* . . .	–	–	"	P. M.	6	1.0330	3.37	9.59	–	–	.59	12.96	87.04
68, . . .	7	8	"	A. M.	7	1.0336	4.08	9.42	5.00	3.73	.69	13.50	86.50
* . . .	–	–	"	P. M.	8	1.0344	3.26	9.75	–	–	.70	13.01	86.99
69, . . .	6	8	"	A. M.	10	1.0330	2.69	9.31	4.75	3.98	.58	12.00	88.00
* . . .	–	–	"	P. M.	10	1.0333	3.05	9.32	–	–	.56	12.37	87.63
70, . . .	6	8	"	A. M.	4	1.0330	6.33	10.36	4.50	5.14	.72	16.69	83.31
* . . .	–	–	"	"	5	1.0352	4.58	10.37	4.60	5.07	.71	14.95	85.05
71, . . .	5	8	"	"	7	1.0334	4.09	10.25	4.40	5.19	.65	14.34	85.66
72, . . .	7	1	"	"	14	1.0330	1.81	8.67	5.05	3.06	.57	10.48	89.52
73, . . .	6	5	"	"	9	1.0352	3.69	9.56	4.90	4.02	.63	13.25	86.75
74, . . .	4	8	"	"	8	1.0355	3.26	9.75	3.60	4.52	.63	13.01	86.99
75, . . .	4	8	"	"	5	1.0330	3.61	10.06	4.40	4.89	.77	13 67	86.33
* . . .	–	–	"	P. M.	6	1.0341	3.72	9.67	–	–	.69	13.39	86.61
76, . . .	6	6	"	A. M.	11	1 0349	3.28	9.89	4.50	4.69	.70	13.17	86.83
77, . . .	5	5	"	"	12	1.0338	2.75	9.38	5.00	3.76	.62	12.13	87.87
78, . . .	6	1	"	"	9	1.0341	4.10	9.76	4.75	4.42	.59	13.86	86.14
* . . .	–	–	"	P. M.	9	1.0322	3.66	9.34	–	–	.62	13.00	87.00
79, . . .	8	5	"	A. M.	8	1.0316	4.06	9.03	4.40	3.94	.69	13.09	86.93
80, . . .	8	1	"	"	13	1.0341	2.71	9.59	4.90	5.01	.68	12.30	87.70
81, . . .	7	2	"	"	12	1.0362	2.95	9.72	5.05	3.99	.68	12.67	87.33
82, . . .	9	2	"	"	8	1.0352	3.61	9.89	4.50	4.77	.61	13.50	86.50

83, . . .	6	2	"	"	10	1.0337	3.22	9.80	4.90	4.30	.60	13.02	86.98
84, . . .	8	2	"	"	11	1.0360	3.24	9.31	5.25	3.59	.51	12.55	87.45
85, . . .	7	5	"	"	12	1.0352	3.09	9.69	4.50	4.55	.64	12.78	87.22
86, . . .	6	3	"	"	6	1.0327	6.02	8.74	4.50	3.60	.64	14.76	85.24
87, . . .	8	2	"	"	9	1.0327	2.82	9.09	4.75	3.71	.63	11.91	88.09
88, . . .	6	8	"	"	13	1.0350	2.86	9.85	4.50	4.72	.63	12.71	87.29
89, . . .	6	5	"	"	7	1.0352	3.15	10.02	5.00	4.42	.59	13.17	86.83
90, . . .	6	6	"	"	9	1.0316	3.35	9.70	4.20	4.88	.62	13.05	86.95
91, . . .	6	7	"	"	12	1.0327	3.05	9.42	5.00	3.84	.58	12.47	87.53
92, . . .	7	1	"	"	10	1.0338	3.73	9.48	4.85	3.97	.66	13.21	86.79
99, . . .	6	5	"	"	7	1.0352	2.92	9.36	4.40	4.32	.60	12.28	87.72
* . . .	–	–	–	P. M.	10	1.0319	3.08	9.39	–	–	.68	12.47	87.53

* The same a few days later.

Average of 16 Holsteins.

	Amount Milk in Pounds.	Percentage Total Solids.
Morning, ...	10.40	12.47
Afternoon, ...	10.08	11.83

Average of 10 Natives at Random.

Morning, ...	8.20	12.99
Afternoon, ...	9.00	12.97

Average of 50 Natives.

Morning, ...	8.90	13.12

It is to be noted, in making comparisons between the Holsteins and natives, that many of the former were very young (two years), and that the conditions of feed and exercise were dissimilar. The natives were kept all day in the stable, while the Holsteins were allowed out in pasture. The feed for natives was "steam feed," which is a hot mixture of bran, corn-meal, rye-meal, oats, ensilage and chopped hay. For the Holsteins the feed was the same, excepting that during part of the day they were given pasturage.

It is of interest to note that although a cow may give a milk below standard, she may, nevertheless, be in some respects (for butter and cheese, for instance) much more valuable as a milk-producer than another giving milk far above the standard, the difference being in the amount yielded in twenty-four hours.

Thus, No. 70 gives a small amount of milk far above the standard, while No. 5 gives a very large amount which falls below the standard, but which yields a much larger absolute weight of solid matter.

The average of the individual analyses would not fairly represent the quality of a mixture of the whole herd's milk, since, usually, the poorer milks are largest in amount.

Summary.

Cities and Towns.	Number above Standard.	Number below Standard.	Total Number.	Percentage of samples below Standard.
20 Cities.				
Boston,	87	108	195	55.38
Brockton,	10	1	11	9.09
Cambridge,	75	97	172	56.40
Chelsea,	29	31	60	51.67
Fall River,	18	11	29	37.93
Fitchburg,	40	9	49	18.37
Gloucester,	11	1	12	8.33
Haverhill,	31	18	49	36.73
Lawrence,	41	17	58	29.31
Lowell,	14	20	34	58.82
Lynn,	20	35	55	63.64
Malden,	18	25	43	58.14
New Bedford,	26	2	28	7.14
Newburyport,	7	5	12	41.67
Newton,	25	12	37	32.43
Salem,	36	12	48	25.00
Somerville,	16	42	58	72.41
Taunton,	7	5	12	41.67
Waltham,	12	9	21	42.86
Worcester,	57	25	82	30.49
	580	485	1,065	45.54
34 Towns.				
Athol,	13	–	13	–
Attleborough,	12	2	14	14.29
Baldwinsville,	7	2	9	22.22
Beverly,	12	15	27	55.56
Brookline,	7	3	10	30.00
Clinton,	24	5	29	17.45
Cottage City,	8	5	13	38.46
Dedham,	1	7	8	87.50
Everett,	3	5	8	62.50
Franklin,	7	2	9	22.22
Gardner,	9	4	13	30.77
Hyde Park,	23	5	28	17.86
Leominster,	24	10	34	29.41
Manchester,	3	3	6	50.00
Marblehead,	4	7	11	63.64
Marlborough,	6	1	7	14.29
Medford,	9	7	16	43.75
Melrose,	6	2	8	25.00
Milford,	34	4	38	10.53

Summary — Concluded.

Towns.	Number above Standard.	Number below Standard.	Total Number.	Percentage of samples below Standard.
Millbury, ...	8	1	9	11.11
Nantucket, . . .	3	–	3	–
Natick, ...	15	4	19	21.05
Northborough, . .	15	1	16	6.25
North Brookfield, . .	8	3	11	27.27
Plymouth, . . .	6	2	8	25.00
Provincetown, . . .	10	2	12	16.67
South Framingham, .	8	3	11	27.27
Spencer, ...	9	3	12	25.00
Stoneham, . . .	5	10	15	66.67
Watertown, . . .	17	4	21	19.05
Webster, ...	11	3	14	21.43
Westborough, . . .	13	1	14	7.14
Winthrop, . . .	3	3	6	50.00
Woburn, ...	17	2	19	10.53
	360	131	591	26.68
Suspected producers, .	59	88	147	59.86
Known purity, . .	46	51	97	52.58
Total, . . .	1,045	755	1,800	41.94

Respectfully submitted,

CHARLES HARRINGTON, M.D.

DR. DAVENPORT'S REPORT ON MILK.

BOSTON, Oct. 1, 1887.

S. W. ABBOTT, M.D., *Secretary of the State Board of Health.*

SIR: — I have to make the following report upon the 1,062 samples of milk which were submitted to me for examination during the past twelve months. Of these, 403, or 37.9 per cent., were found not to be of the good standard quality required by the milk statute. This is a great improvement over the 66.6 per cent. found to be below in my last year's report. Of these milks, 45, or 4.2 per cent., were found to contain annotto coloring-matter. This is the coloring commonly used in the so-called milkman's "benefit," as it is known in the trade, — so called, doubtless, because he alone gains any benefit from its use, as he is enabled thereby to palm off upon his unsuspecting customers skimmed or watered milk as whole milk. In my last report, 16.2 per cent. of all the samples were found to be thus tampered with by coloring. In this respect, also, there has been a great gain made.

There is another very strong reason why this coloring of milk with annotto should not be tolerated besides its aiding to cover up fraud, as mentioned in my last report, and it is this. It is stated in most of the standard works upon *materia medica* which mention annotto, that the coloring-matter is obtained from the seeds of the tropical plant *Bixa Orellana*, by allowing them to macerate and undergo a fermentation in water. The color thus separated from the seeds settles out from the water on standing, and collects upon the bottom of the vessel. The water is drawn off, the color gathered up, dried somewhat, and formed into

cakes. That prepared in French Guiana is considered the superior brand of the dyestuff. There, in the warehouses, it is reported to be the general commercial custom to improve the color of the dyestuff, and prevent its drying, by keeping the cake moistened with stale urine. The result of all this is that the commercial dyestuff is a mass of fermentative products, swarming with germs of putrefaction, and smelling rankly of its stale origin. Microscopic examination of the "benefit" prepared and sold by the best known maker in the business in this city shows that it is not only alive with bacteria, but that it contains very numerous *fungi* spores, single and arranged in rows, like those which are to be found in fermented diabetic urine. Surely this is not a very delectable substance to think of as being added to the food of our tender infants, to say nothing of our invalids, and of ourselves who are so fortunate as to be well and strong. Considering that, in the opinion of some of our best observers, the very great known advantage in its chances of living which a breast-fed infant has over a bottle-fed one is very largely due to the fact that the breast-milk escapes all possible chances of putrefactive germ contamination, the direct and wilful addition of any such fermentative substance as annotto coloring-matter should not be tolerated. A solution of about one part of this dyestuff in twenty of a solution of caustic soda or potash constitutes the preparation so well known among the milk pedlers as "benefit." The same coloring, dissolved in cotton-seed or some other similar oil, is the well-known dairy article, "butter and cheese color," mentioned in my report upon foods. By adding about one teaspoonful of the above "benefit" to from fifty to one hundred quarts of milk, some thrifty milk pedlers will make that quantity of their most skimmed and watered milk take on the color of rich whole Jersey milk. It is, however, well known in the trade that such a colored milk will not keep so long as if the coloring had been left out, — a fact not to be wondered at considering the origin of the color.

The method of analysis followed has been that set forth in full detail in my last year's report to the Board. In cases where the presence of annotto coloring was detected by the

method there described, I have followed the very convenient method practised by Prof. J. F. Babcock at the city milk inspection office, which is as follows: About a gill of the milk is curdled by heating, after the addition of a few drops of acetic acid. The curds, which contain all the coloring, are strained off as dry as possible, and than rubbed up in a small mortar with two or three successive portions of ether. A sufficient quantity is used at a time to cover the curds in the mortar, and after the rubbing up allow about ten c.c. to be poured off. The successive portions of ether are collected together into a small globe separating funnel, and then shaken out twice with about half an ounce of water, which has been made with caustic soda not much more than distinctly alkaline to test paper. This alkaline water extracts the color from the ether. In the two portions united in a small capsule, small disks of thick white filter paper, which can be conveniently cut out by a gun-wad punch, are allowed to macerate until they have abstracted all the color. This they will do more quickly if heated on the water-bath. Thus practically all the coloring in a gill or more of the milk can be concentrated into a few small disks of paper, and its apparent shade thus very greatly heightened over that obtained in the preliminary test. When the disks have been dried, one should be preserved just as it came from the bath, and the coloring-matter upon the others submitted to the reactions necessary for its identification. They are then made up into a convincing exhibit by being fastened with fresh arrowroot paste upon a stiff card, so that they can be conveniently handled.

If, instead of annotto, caramel is the coloring-matter used in the milk, it is detected in the following manner, which was likewise devised by Prof. Babcock: About a gill of the milk is curdled by adding it to as much strong alcohol. The whey is filtered off and a small quantity of lead subacetate added to it. The precipitate thus produced is collected upon a small filter, which is then dried in a place free from any hydrogen sulphide gas. A pure milk thus treated yields upon the filter paper a residue which is either wholly white, or, at the most, of a very light straw color, while in the presence of any caramel the residue is of

a more or less dark brown color, according to the amount of coloring present. The colored residue thus obtained can be made to adhere to one of the small paper disks by a little of the arrowroot paste, and then the disk mounted upon a card in like manner as with annotto. By these methods the presence of either coloring, if in sufficient amount to be of any practical effect in coloring the milk, is readily detected.

The efforts made by the Aylesbury Dairy Company of London, England, offer an example of the plan of action which should be followed by all the dairy companies in this State, to furnish to their customers not only an unadulterated but also a healthful milk, — that is, milk from healthy cows, fed and kept under proper sanitary conditions. Yet so far as I now know, — and I have used due diligence in seeking to inform myself of all there are, — there is not a single dairy company in this State which even approximates to the half of the care which is exercised by this English company to deliver into the hands of its patrons a milk sound in all respects from its very beginning.

The dairy companies of this State seem to consider themselves overburdened when called upon to see somewhat to it that their milk is not actually skimmed and watered. Most of them make no pretense at all of having any knowledge as to its manner of production. Before our city milk supply can become at all what it ought to be, all this must be greatly changed. Then we may hope that, as with the Aylesbury company, the night's and morning's milk will each be brought into the city and distributed even before the other is milked, and the greater part of our milk may not be, as now, in its third day of age when consumed. Such a change would, no doubt, contribute very largely to the life and healthfulness of the infant population in our crowded cities.

Respectfully submitted,

BENNETT F. DAVENPORT.

PROFESSOR GOESSMANN'S REPORT.

WESTERN MASSACHUSETTS.

The following report comprises a summary of the results of analyses of milk obtained in the cities and towns of Western Massachusetts, for the year ending Sept. 30, 1887: —

The whole number of samples examined was,	219
Number above standard,	196
below standard,	23
Percentage below standard,	10.50
Number of samples having between 12½ and 13 per cent. of solids,	15
of samples having between 12 and 12½ per cent. of solids,	16
of samples having between 11 and 12 per cent. of solids,	2
Below 11 per cent.,	0

This is a better result than that of any previous year, and is in marked contrast with the results of analyses of milk obtained under like conditions by the same inspectors in Eastern Massachusetts.

The statistics of the different cities are as follows: —

HOLYOKE.

Number of samples,	58
above standard,	47
below standard,	9
Percentage below standard,	15.52
Skimmed,	2
Lowest, not skimmed,	12.25

NORTHAMPTON.

Number of samples,	12
above standard,	9
below standard,	3

Percentage below standard,	25.00
Lowest,	12.03

SPRINGFIELD.

Number of samples,	33
above standard,	28
below standard,	5
Percentage below standard,	15.15
Lowest,	11.95

The results in the remaining towns were as follows: —

	Above Standard.	Below Standard.	Total.
Amherst,	7	1	8
Chicopee,	14	–	14
Lee,	6	1	7
Miller's Falls,	10	–	10
North Adams,	11	1	12
Palmer,	12	2	14
Pittsfield,	13	–	13
Turner's Falls,	14	–	14
Ware,	11	1	12
Westfield,	12	–	12

C. A. GOESSMANN.

REPORT OF THE ANALYST OF DRUGS.

REPORT OF THE ANALYST OF DRUGS.

BOSTON, Oct. 1, 1887.

S. W. ABBOTT, M. D., *Secretary State Board of Health.*

SIR: — I have the following report to make upon the 550 samples of drugs which have been submitted to me for examination during the past twelve months, and of which I found 150, or 27.2 per cent., not to be of their proper standard quality. In my last report the percentage of poor samples was 45.8 per cent., in which respect the past year shows a decided improvement. As stated in my previous reports, it is not to be understood that such large percentage of all the drugs sold are of a poor quality. The drugs selected for examination were collected because they were known to be specially liable to adulteration; the above-mentioned percentages only were found to be actually poor upon examination.

The following are the groups of drugs and the result of their examination: —

Potassium Bitartrate, 37 samples. Were all of standard quality except two. One of these had about 60 per cent. of lime sulphate, and the other nearly as much of acid phosphate of lime and starch.

Potassium Iodide, 15 samples. All but one had an excess of chlorides and of carbonates.

Oils, of the fixed and volatile mentioned in the United States Pharmacopœia, 93 samples. Of these all but 13 were of their proper quality.

Jalap, 15 samples. All but 2 fairly contained the required amount of total resins and of that not soluble in ether.

Powdered samples of the United States Pharmacopœia, spices and other vegetable drugs, 66 in number, were submitted to microscopic examination. Of these 7 were found to contain foreign ingredients; nearly all of them were mustard, and the adulterant flour.

Chloral Hydrate, 15 samples. Were all of good quality.

Pepsin, 6 samples; of which 3 did not have the required amount of digestive activity.

Iron, Saccharated Carbonate, 9 samples. Were all of good quality.

Bismuth Subnitrate, 5 samples. Were all of correct quality.

Glycerine, 7 samples. Were all of fair quality.

Menthol, 4 samples. Were of standard quality.

Alcohol, 6 samples. Were all of proper strength, and agreed as well with the United States Pharmacopœia tests for foreign organic impurities as could be expected from the customary storage of it in barrels.

Whiskey, 4 samples. But one of these agreed with the requirements of the United States Pharmacopœia,—that is, was the straight, natural distilled spirit, mellowed only by time. All the others had been submitted to the processes of the mixers, blenders and other so-called improvers, who are miscalled rectifiers, at least in the ordinary meaning of the term.

Brandy, 16 samples. Not one of them was the natural article demanded by the Pharmacopœia, but every one of them had met the misadventure which had befallen the most of the whiskey samples. It does seem that at least enough to supply the legitimate pharmaceutical needs of the country should be obtainable from our own domestic production in California and some of the other States, even if there is no reasonable expectation of obtaining it from abroad.

Wine, 12 samples. The same was true of all but one of these samples as was of the brandy samples. None were the natural article called for by the requirements of the United States Pharmacopœia. They had undergone an even more varied experience than the samples of whiskey and brandy. For, wine being naturally a fluid of a more complex composition than distilled spirits, it allows of a greater range of variation in other respects besides the coloring. It is very unfortunate that the two imported wines in most general medical and pharmaceutical use, port and sherry, are more generally sophisticated than any other sold in our market. The analyses of natural native wines, however, which were made by Prof. Henry B. Parsons, and published in the Report of the United States Department of Agriculture for 1880, show that they at least conform to the requirements of the United States Pharmacopœia, which were in fact based upon them. That the ordinary manufactured wines are likely to prove any more injurious to the health of consumers than would natural wines, has not yet, I think, been fairly demonstrated. Yet to sell them for natural wines is none the less a fraud.

Spirits of Nitrous Ether. Fourteen samples have been examined, and only two of them were found to fairly contain the required percentage of ethyl nitrite. From some of them it was well nigh totally absent. Probably this was largely due to the improper manner in which the preparation is commonly stored, as was mentioned in my last report.

Compound Spirits of Ether. Thirteen samples have been examined and 5 of them found to fairly contain the required amount of heavy ethereal oil. This is a much larger proportion than was found in any previous year.

Tincture of Nux Vomica. Thirty samples were examined, and only 6 of them were found to have just the proper amount of 2 per cent. of extract. They ranged from 0.92 per cent. to 5.81 per cent. of extract, one thus being over six times as strong as another. There were 15 of them above and 9 below the proper strength. Their average was 2.24 per cent. This is a preparation for which there is no valid excuse for any essential variation from the exact amount, when one considers its method of preparation; for if the very simple directions of the Pharmacopœia are followed, the desired definite result will be secured.

Quinine and its Sulphates. Forty samples were examined, and all were found to be fairly within the pharmacopœial requirements of purity.

Citrate of Iron and Quinine. Thirty-eight samples were examined, and all but 3 were found to be fairly up to the standard required for percentage of alkaloid. This is a very great improvement over what has been found in previous years, when about three-fourths of the samples have been found to be deficient in the alkaloid. The general substitution of the unofficinal ammonia form of the preparation, however, continues, as it should not.

Opium in the forms of Gum, Powder and Pill. Twenty-seven samples were examined and all but 2 were found to fairly contain the pharmacopœial amount of morphine. In no previous year have many more than half of the samples been found to be up to the standard. Thus there has been a very great improvement in regard to this very important drug. The poorest yield of morphine in any sample of powder has been 11.40 per cent. and the best 14.76 per cent. The poorest gum had 9.50 per cent. and the best had 13.80 per cent. The commercial drug as found sold in this State thus seems now to be of very good quality.

Opium as Tincture, simple and deodorized. Forty-two samples were examined and but 9 were found not to be fairly of the standard quality. In no previous year have quite half of the samples been found to be up to the required standard. The highest percentage of morphine yielded by any sample was 1.59 per cent., and the lowest 0.58 per cent., which was thus only about one-third as much as in the highest, and less than half of the required amount. Their average was 1.24 per cent., the requirement being 1.20 per cent. In my report made in 1883 upon the first general collection of samples made throughout the State the average was but 0.96 per cent. and 82 per cent. of the samples fell below the standard, while some were six times as strong as others, which were only about one-fourth the required strength. Thus in this preparation, which is one of the most important of all those used in medicine, the very great improvement which has been brought about through the influence of our State adulteration law is made very manifest.

Besides the above-mentioned pharmacopœial drugs and their preparations, I have examined the following list of 50 samples of proprietary preparations, tonics and bitters, with special reference to the relation which the percentage of alcohol which they were found upon assay to contain might bear to the admission of the presence of any or claims for the absence of all alcohol, as given upon their labels and wrappers. I have also noted the doses and frequency with which they were recommended to be used, as well as the place of their origin. The alcohol found upon assay is given in per cent. by volume. How far the claim of some of them for special usefulness in the reformation of intemperate habits is justified is self-evident.

Tonics.

Dr. Buckland's Scotch Oats Essence, New York City. "Enough alcohol is added to dissolve resins, and prevent fermentation." "Not a temporary and fleeting stimulant, but a permanent tonic. Its use must be regular and continued over a considerable period. An extract of double and triple strength also made. Dose, 10 to 15 drops, to a teaspoonful three or four times daily, increased as needed." In the simple essence 35 per cent. of alcohol was found on assay. Further examination of this article reveals a still more dangerous ingredient in its composition. The sample analyzed was found to contain one-fourth grain of morphia to the ounce of the so-called "Essence of Oats." A more insidious and dangerous fraud can scarcely be imagined, especially when administered, as this is recommended, for the cure of inebriety or the opium habit.

The "Best" Tonic, Milwaukee, Wisconsin. "A concentrated liquid extract of malt and hops. Neither alcohol nor spirits used in its preparation. Dose, from a wineglassful to a pint bottle full per day." Percentage of alcohol found, 7.65.

Carter's Physical Extract, Georgetown, Mass. Dose, 1 tablespoonful, 3 times daily. 22 per cent. of alcohol found on assay.

Hooker's Wigwam Tonic, Haverhill, Mass. One tablespoonful, 3 times daily. 20.7 per cent. of alcohol found on assay.

Hoofland's German Tonic, Philadelphia. Admits Santa Cruz rum. Wineglass, 4 times daily. 29.3 per cent.

Hop Tonic, Grand Rapids, Mich. One tablespoonful to wineglass, 3 times a day. 7 per cent.

Howe's Arabian Tonic, New York. "Not a rum drink." Tablespoonful to wineglass, 4 times daily. 13.2 per cent.

Jackson's Golden Seal Tonic, Boston. Admits Marsala wine. Half wineglass, 3 times daily. 19.6 per cent.

Liebig Co.'s Coca Beef Tonic, New York. "With sherry." Two to four teaspoonfuls, 3 times daily. 23.2 per cent.

Mensman's Peptonized Beef Tonic, New York. "Contains spirit." One tablespoonful to 3, 3 times daily. 16.5 per cent.

Parker's Tonic, New York. "A purely vegetable extract." "Stimulus to the body without intoxicating." "Inebriates struggling to reform will find its tonic and sustaining influence on the nervous system a great help to their efforts." Dose as tonic 1 to 2 teaspoonfuls, 1 to 3 times daily. 41.6 per cent.

Schenck's Sea-Weed Tonic, Philadelphia. "Distilled from sea-weed after the same manner as Jamaica spirits is from sugar-cane. It is therefore entirely harmless, and free from the injurious properties of corn and rye whiskey." Dose, half wineglass, 3 times daily. 19.5 per cent.

Bitters.

Atwood's Quinine Tonic Bitters, Boston. Dose, half tablespoonful to half wineglass, mixed with water, wine or spirit, 3 times daily. 29.2 per cent.

L. F. Atwood's Jaundice Bitters, Portland, Me. Half tablespoon to half wineglass, 1 to 6 times daily. 22.3 per cent.

Moses Atwood's Jaundice Bitters, New York. Half tablespoon to wineglass, 1 to 6 times daily. 17.1 per cent.

H. Baxter's Mandrake Bitters, Burlington, Vt. One to 2 tablespoonfuls. 16.5 per cent.

Boker's Stomach Bitters, New York. Dose not given. 42.6 per cent.

Brown's Iron Bitters, Baltimore, Md. "Perfectly harmless." "Not a substitute for whiskey." Tablespoonful. 19.7 per cent.

Burdock Blood Bitters, Buffalo, N. Y. Teaspoonful to tablespoonful, 3 times daily. 25.2 per cent.

Carter's Scotch Bitters, Georgetown, Mass. Tablespoon to wineglassful, as occasion requires. 17.6 per cent.

Colton's Bitters, Westfield, Mass. Teaspoon to 2 tablespoonfuls, 3 times daily. 27.1 per cent.

Copp's White Mountain Bitters, Manchester, N. H. "Not an alcoholic beverage." Wineglassful. 6 per cent.

Drake's Plantation Bitters, New York. "Contains St. Croix rum." Wineglassful, 3 times daily. 33.2 per cent.

Flint's Quaker's Bitters, Boston. Teaspoonful, 6 times daily. 21.4 per cent.

Goodhue's Bitters, Salem, Mass. Half wineglassful. 16.1 per cent.

Hartshorn's Bitters, Boston. Tablespoon to half wineglassful. 22.2 per cent.

Hoofland's German Bitters, Philadelphia. "Entirely vegetable and free from alcoholic stimulant." Tablespoonful, 4 times daily. 25.6 per cent.

Hop Bitters, Rochester, N. Y. One to 3 tablespoonfuls, 3 times daily. 12 per cent.

Hostetter's Stomach Bitters, Pittsburg, Pa. Wineglassful, 3 times daily. 44.3 per cent.

Kaufmann's Sulphur Bitters, Boston. "Contains no alcohol." Tea to tablespoonful. It contains no sulphur, but has 20.5 per cent. of alcohol.

Kingsley's Iron Tonic, Northampton, Mass. One to 2 teaspoonfuls, 3 times daily. 14.9 per cent.

Langley's Bitters, Boston. Half wineglass or more, 3 times daily. 18.1 per cent.

Liverpool's Mexican Tonic Bitters, Boston. Half to full wineglassful, 3 times daily. 22.4 per cent.

Oxygenated Bitters, New York. Tea to tablespoonful. Acid but no alcohol.

Pierce's Indian Restoration Bitters, Boston. Up to wineglassful, and to 6 times daily. 6.1 per cent.

Z. Porter's Stomach Bitters, New York. Tablespoonful or more several times daily. 27.9 per cent.

Rush's Bitters, New York. Wineglassful, 4 times daily. 35 per cent.

Dr. Richardson's Concentrated Sherry Wine Bitters, Wakefield, Mass. Tablespoonful to half wineglass or more, 3 times daily, "or when there is sensation of weakness or uneasiness at the stomach." 47.5 per cent.

Secor's Cinchona Bitters, Providence, R. I. Half wineglassful, 3 times daily. 13.1 per cent.

Shonyo's German Bitters, Concord, N. H. Table to wineglassful. 21.5 per cent.

Job Sweet's Strengthening Bitters, New Bedford. Tablespoonful to wineglassful, 3 times daily. 29 per cent.

Thurston's Old Continental Bitters, Lynn, Mass. Tea to 2 tablespoonfuls. 11.4 per cent.

Walker's Vinegar Bitters, New York. "Free from all alcoholic stimulants. Contains no spirit." Half to full wineglass. 6.1 per cent.

Warner's Safe Tonic Bitters, Rochester, N. Y. Table to wineglassful, 35.7 per cent.

Warren's Bilious Bitters, Boston. Teaspoon to 2 tablespoonfuls, 1 to 3 times daily. 21.5 per cent.

Wheeler's Tonic Sherry Wine Bitters, Boston. Two-thirds wineglass, 2 times daily. 18.8 per cent.

Wheat Bitters, New York. Dessert to wineglass, 3 times daily. 13.6 per cent.

Faith Whitcomb's Nerve Bitters, Boston. Tablespoonful, 3 times daily. 20.3 per cent.

Dr. William's Vegetable Jaundice Bitters, Lowell, Mass. Half to full wineglass, 1 time daily 18.5 per cent.

Respectfully submitted,

BENNETT F. DAVENPORT.

REPORT ON OLEOMARGARINE.

REPORT.

The Legislature of Massachusetts at its last session, after having considered certain questions relative to the manufacture and sale of imitations of dairy products, enacted the following order: —

Ordered, That the State Board of Health be requested and required to make a special investigation and report to the next General Court upon the manufacture and sale of oleomargarine and butterine, especially with reference to their healthfulness as articles of food, and as to the question whether they are sold in compliance with existing laws.

In compliance with the foregoing order, the State Board of Health appointed Dr. E. G. Brackett, of Harvard Medical College, to consider and report upon the question of the healthfulness of oleomargarine and butterine as articles of food.

The remaining portion of the inquiry, relative to the manufacture and sale of oleomargarine and the question of compliance with existing laws, is embraced under the following topics: —

1. General View of the Subject and its Importance.
2. Inspection of Establishments where Oleomargarine and Oleo Oil are Manufactured in Massachusetts and in other New England States.
3. Protection Afforded by Existing Laws, and Extent of Compliance with such Laws.
    - (*a*). *Inspection under the National Law.*
    - (*b*). *State Inspection.*
    - (*c*). *Local Inspection.*
4. Summary and Conclusions.

For the sake of convenience, and as a matter of conformity to the terms employed in the national and the State laws,

the term "oleomargarine" will be used in this report to include all substances made in imitation of butter, as now manufactured and offered for sale in Massachusetts. As now made in most of the factories in the United States, oleomargarine is a more complex substance with reference to the number of ingredients entering into its composition than that which was at first proposed and made in France, which consisted mainly of melted beef fat, churned with milk, to which coloring-matter and salt were added.

1. General View of the Subject.

The process of manufacture of artificial butter was discovered by Mége Mouries in 1867, but for ten years or more its manufacture had not assumed such proportions as to affect the sale of genuine butter in this country.

The experiments of Mége Mouries were at first conducted under the authority of the French government. A factory was established for its production at Poissy, near Paris, and the product was first named "margarine."

The outbreak of the Franco-German war in 1870 caused the suspension of operations, but they were resumed after the war, and in 1872 the Council of Health of the Department of the Seine admitted the new product as a legitimate food-product, on condition that it should not be sold as butter.

The process was patented in England in 1869 and in the United States in 1873. We do not find that any of the parties whose establishments have been visited are at present making it under any patented process.

It is only within the past ten years that the manufacture of oleomargarine has assumed such extensive importance as to require special legislation for the purpose of regulating or of prohibiting its manufacture and sale. Within these latter years a majority of the United States has enacted laws with reference to this subject, and in ten of this number such laws are prohibitory. In a very small number, however, so far as can be learned, are such laws stringently enforced.

In Europe, oleomargarine is largely manufactured in Germany, Holland, Belgium and France. Holland exports very large quantities to other European countries. Oleomar-

garine oil in the crude form is exported in large quantities to Holland for further manufacture. The quantity exported from the United States to Holland in 1886 was 114,300 tierces of about 300 pounds each, being nearly half of the entire amount exported.

The revenue receipts from the manufacture and sale of oleomargarine in the United States for the first eight months after the enactment of the national law were $723,948.04, of which $435,934.04 was the tax on 21,796,202 pounds at two cents per pound. The actual tax derived by dividing the total revenue by the number of pounds was three and three-tenths cents per pound.

During the first four months of the following year, July 1 to Nov. 1, 1887, the revenue was $226,100.66, making the total receipts for the first year under the operation of this law $950,048.70.

In 1880 the United States exported 39,236,655 pounds of butter and 20,000,000 pounds of oleomargarine. In 1885 the exportation of butter had diminished to 21,638,128 pounds, and that of oleomargarine had increased to nearly 38,000,000 pounds. The oleomargarine thus exported was mainly in the crude form of oleo oil.

The second report of the Dairy Commissioner of New York states (p. 316) that in 1883, 10,000,000 pounds were sold in New York City alone, and about 45,000,000 in the United States.

In the course of the congressional inquiry of 1886, evidence was presented that Kansas City produced 6,000 pounds of oleomargarine daily, Chicago over 100,000 pounds daily; St. Louis produced 250 tierces per week of oleo oil for shipment to Rotterdam, Kansas City 200 tierces and Chicago over 1,200 tierces per week. The Providence Dairy Company made 1,750,000 pounds of butterine in 1885, Cincinnati 766,000 pounds, Nathan & Co., of New York, 2,000,000 pounds, Reardon & Sons, of Boston, 2,740,000 of oleomargarine and 1,158,000 pounds of oleo butter. The Woodlawn Dairy Company, of Pawtucket, R. I., made 931,000 pounds of oleomargarine in the same year.

The value of these products exported rose from $70,000 in 1876 to $4,842,000 in 1884, and $4,451,000 in 1885.

The exports of oleomargarine in the shape of butter were about 2,000,000 in 1882, and have fallen very much since that date. The exports of oleo oil increased from 19,000,000 pounds in 1882 to 37,000,000 in 1884 and 1885, and then decreased very considerably.

The comparative importance of this inquiry as affecting the interests of Massachusetts will be better understood on referring to the statistics relative to the number of dealers in oleomargarine in different States, on a later page of this report. In that summary the number of retail dealers in oleomargarine in the State during the first six months under the new law is stated as 411. At the close of the year the number had apparently been reduced by the action of the national law to 247, which was about one-sixth of the number in the United States. This number has increased considerably since June 30, 1887, being now (March 23) 395.

In the matter of revenue from the taxes upon oleomargarine Massachusetts stood at the close of the last fiscal year the fourth in the order of States, the amounts for each State being as follows:—Illinois, $266,057.04; Rhode Island, $84,275.36; Indiana, $57,421.50; Massachusetts, $53,686.70.

In the three States, Illinois, Indiana and Rhode Island, the greater part of the revenue is derived from the manufacturers, while in Massachusetts the dealers contribute by far the largest part of the tax, thus showing that from a relative point of view, while the interests of the former States are most largely concerned in the production of the article, those of this Commonwealth are mainly concerned in its consumption

From the data given in these tables it appears that the manufacture and sale of oleomargarine is confined mainly to eleven of the northern States, of which number Colorado, Illinois, Indiana, Kansas, Michigan and Ohio are chiefly agricultural States, and Connecticut, Massachusetts, New York, Pennsylvania and Rhode Island are manufacturing and mining States.

Of these States Illinois paid the largest tax ($211,293.04) on the manufactured product, representing 10,564,652 pounds. Rhode Island was next in order, Indiana third,

New York fourth, Kansas fifth, Ohio sixth and Massachusetts seventh.

From retail dealers the largest tax was collected in Illinois. Massachusetts was next in order, Rhode Island third, Pennsylvania fourth, Michigan fifth and Ohio sixth.

From wholesale dealers the largest tax was collected in Massachusetts, the second in Illinois, the third in Michigan, the fourth in Rhode Island, the fifth in Pennsylvania, the sixth in New York.

Thus it appears that Illinois is both a producing and consuming State with reference to oleomargarine. Indiana produces it largely and consumes but little, the same being true of Kansas. Rhode Island is a large producer and consumer, while Massachusetts is comparatively a large consumer of oleomargarine.

Since these figures pertain chiefly to the transition period between the date of non-taxation and taxation of this product, it is quite evident that they may undergo material changes in a succeeding year. The results of inquiry, as shown in the report of the Commissioner of Internal Revenue for 1887, have already foreshadowed such a result.

With reference to the causes which have led to the manufacture and sale of substitutes for butter, allusion has already been made in former reports of the Board, especially in the Supplement to the Fifth Annual Report of the State Board (1883), where a statistical table relative to the production of milk, butter and cheese in Massachusetts is given. In the same connection density of population was shown to be an important concomitant factor relative to the adulteration of milk. It was shown that in the eastern section of the State, where the population has a density of about 450 to the square mile, and especially in the large cities and their suburbs, adulteration of milk was very prevalent, while in the western counties, where the density is not more than 100 to the square mile, milk adulteration is practically unknown. The experience of the Board in its constant supervision of inspection of milk confirms this statement. To a considerable extent this may also be said to apply to butter.

The number of milch cows in Massachusetts in 1855 (State Census) was 148,569. In 1885 it was 162,847, an

increase of 9.6 per cent. in thirty years, while the population had increased in the same period from 1,132,364 to 1,942,141, or 71 per cent., or in other words a decrease from one cow to 7.6 inhabitants to one in 12.1.

Massachusetts has become (with the single exception of Rhode Island) the most densely populated State of the Union,— the density in 1885 being 233.5 persons to the square mile; and while in the western counties of the State there is still abundant room for grazing purposes, in the eastern, and especially in districts near large cities, the land is fast becoming too valuable for such uses. As a consequence the work of the dairyman becomes more and more restricted to narrow limits.

Genuine butter must be made from comparatively fresh milk and usually in places within easy distance of milk-producing farms. The amount produced in Massachusetts, as reported for the year 1885, the year of the State Census, was 9,685,539 pounds; the amount reported in 1845, forty years previous, was 7,688,566 pounds. The population between these two dates had doubled, but the production of butter in the same time had increased but 26 per cent.

The comparative statistics relative to the production of butter in the State will be found in the accompanying table, wherein will also be found the number of cows in the State in each year of the State Census. Here, also, the figures have not kept pace with the population, although a slight increase has been noted in the last decade. The importance of the latter item as influencing the production of butter will not require further explanation.

Statistics relative to Butter Production in Massachusetts,— 1845–1885. (From State Census.)

	1845.	1855.	1865.	1875.	1885.
Butter (pounds),	7,688,556	8,116,009	3,745,293	7,922,431	9,685,539
Total value,	$1,116,709	$1,678,558	$1,360,248	$2,747,878	$2,531,071
Value per pound,	$0 15	$0 21	$0 36	$0 35	$0 26
Cows,	–	148,569	143,286	126,034	162,847
Ratio of cows to population,	–	1 to 7.6	1 to 8.8	1 to 13.1	1 to 12.1

To supply the deficiency in the production of butter considerable importations have been made from other States, and finally the substitute, oleomargarine, has made its way into every city and almost every town in the State, and whatever may be said of its healthfulness as an article of food, the effect upon the producer of true butter must necessarily be a disastrous one so long as the imitation can be produced at a lower price, especially if it is made in exact imitation of and sold as genuine butter.

2. Inspection of Manufactories.

The establishments visited were one in Massachusetts, four in Rhode Island, and one in Connecticut for the manufacture of oleomargarine, and one in Massachusetts for the production of oleo oil.

The process of preparing oleo oil as conducted at Brighton, Mass., is as follows:—This establishment as a matter of convenience is located at the abattoir where cattle are slaughtered for food purposes. In some instances the various processes, from the slaughtering of the beeves to the conversion of their fat as combined with other materials into oleomargarine, are conducted in one establishment, while in others the various stages are carried on independently.

Immediately after the animals are killed the fresh intestinal and caul fat are removed and placed in tanks of water at a temperature of about 80° F. From this water they are transferred to other tanks of cold water and chilled until all animal heat is removed. The fat is then cut or hashed into small pieces and melted at about 150° F. in jacketed steam-kettles, until the clear oil is entirely separated from the connective tissue.

This oil is then drawn off into vats, which, on account of the appearance of the oil on cooling, are called graining or seeding vats, where it is allowed to stand for twenty-four hours or more, at a temperature of about 85° F. From these vats this semi-solid emulsion of oil and stearine is dipped into cloths which are folded and placed in a press between sheets of metal, and subjected to powerful pressure. By this means the oil is separated from the stearine and is drawn into casks for export or for manufacture into oleomargarine. Large

quantities are annually exported to Holland, where it is manufactured, and either sold for consumption in that country or re-exported to other countries in Europe.

The inspection of this establishment was made without previous notice to the proprietors, and it was found to be in a clean condition. The animals used for slaughter appeared to be sound and healthy, and the various processes from the time of slaughtering to the final reception of the oil into tierces for further manufacture or for export were conducted with such care and neatness as would ensure a wholesome product. The abattoir at which oleo oil is made in Massachusetts is under the supervision of the Board of Health of the city of Boston.

The further details of the process were inspected and examined at factories in Cambridge, Mass., in Providence and Pawtucket, R. I., and in New Haven, Conn. These further processes consist in mixing the oleo oil, thus obtained with other substances in a churn, these substances being chiefly milk, genuine butter, refined lard and some vegetable oil, such as cotton-seed or sesame or peanut oil, together with a small quantity of coloring-matter, which is usually annotto prepared by boiling in oil.

The genuine butter used for the purpose is employed to give the product a good butter flavor, which is impossible without the use of genuine butter. For this purpose butter of a decided taste and flavor is usually employed. The proportions of those substances used vary with the season of the year, and also with the caprices of different manufacturers.

The following were stated as proportions commonly employed by firms who testified at the congressional inquiry in June, 1886: — "Creamery butterine" usually composed of 25 per cent. of butter, 40 per cent. neutral lard, 20 per cent. oleo-oil, remainder milk, cream and salt; "dairy butterine" 10 per cent. of butter, 45 per cent. neutral lard, 25 per cent. oleo-oil, remainder milk, cream and salt.

At some of the establishments visited in connection with this inquiry the amount of lard employed was stated as much less than the proportion just quoted. Sesame or benne and cotton-seed oil were also used.

After these ingredients have been sufficiently churned the

mixture is let out into a vat or tank of ice-water containing floating ice. In one establishment the current flowing from the churn was met by a spray of ice-water from a hose. The floating mass is removed from the tank and conveyed to a kneading machine, where it is worked and moulded and the proper amount of salt is added. The remaining processes consist in the packing of the oleomargarine into tubs, casks, boxes, or into small lumps of a pound, a half pound, or two pounds each.

These factories were also visited without previous notice, and in every instance opportunity was freely granted to witness and inspect the various processes in the minutest detail as well as the materials employed in their manufacture into the completed product.

In general the methods of operation were conducted with neatness, the employees were also cleanly in their personal appearance, and the materials used were wholesome so far as could be judged by the evidence of the senses. As compared with each other there were differences in the degree of cleanliness in different establishments, as is also true in other factories devoted to the preparation of food-products, such as creameries, bakeries, slaughter-houses, sugar refineries, grist-mills, etc.

Coloring-Matter. — Since the question of coloring-matter in oleomargarine has been a question of recent consideration by the Legislature, a brief statement in relation to it may not be deemed out of place in this report.

The coloring-matter which was found in use at all of the establishments visited was annotto. This coloring material is also the principal substance used for coloring genuine butter.

Annotto is the red envelope of the seeds of the *Bixa orellana*, a South American tree. These seeds are quite small (about four or five millimetres in length when dry) and brittle. They have a nutty flavor and are slightly bitter. They will impart their color to alcohol, ether, oils and to alkaline solutions. For the purpose of coloring oleomargarine they are usually prepared by boiling in oil. They are not known to be injurious to health in the proportion in which they are ordinarily used for coloring oleomargarine.

The two heliotypes are introduced to illustrate two of the important mechanical processes concerned in the manufacture. In the first illustration is shown one of the presses used for separating the oleo-oil from the stearine. At the right hand is shown one of the movable tanks in which the oil is placed for several hours, where it assumes a semi-solid consistence, and from them it is dipped into cloths, which are shaped in boxes upon the rotary stand in the middle of the room. These cloths are placed in layers in the presses, one of which is shown as ready for pressing, and in the other the material has been pressed and the oil is issuing from it.

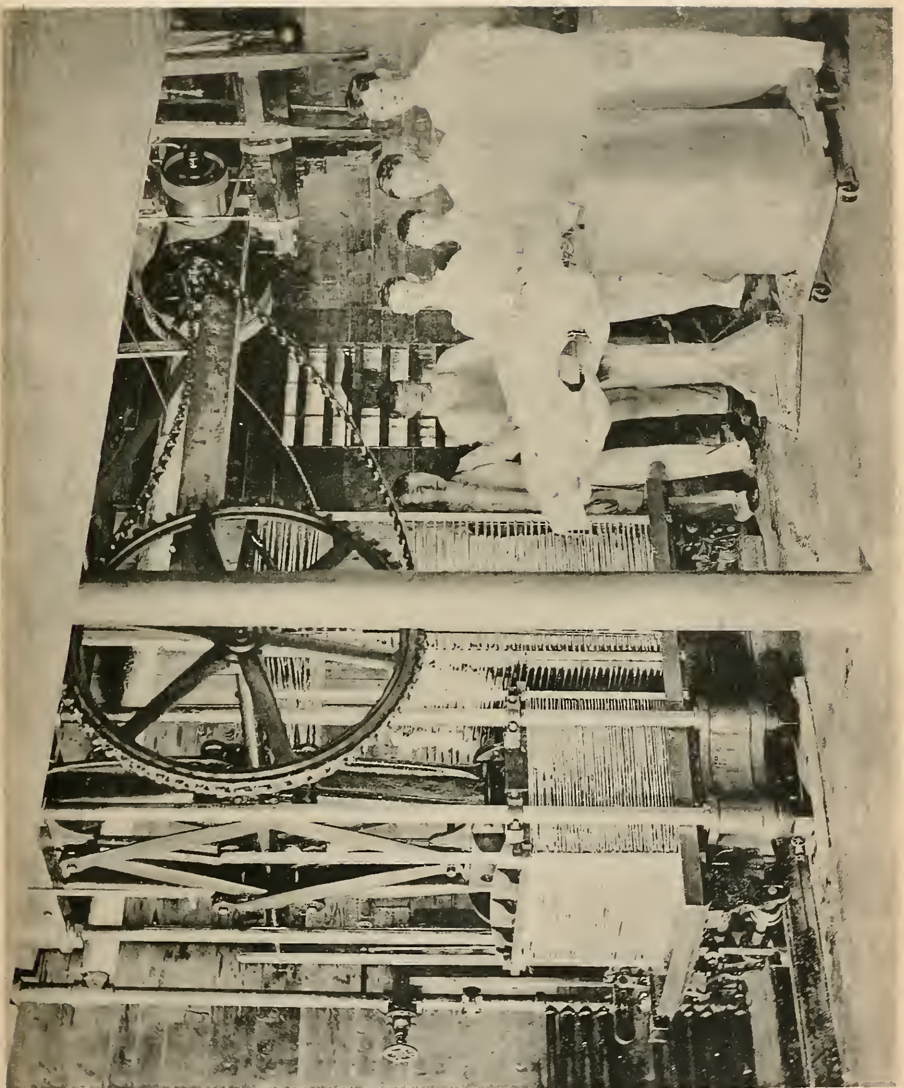
In the other illustration is shown the churn, into which are placed the different materials, and from which the oleomargarine flows, in a liquid state, into the tank of cold water. A hose is represented crossing the figure diagonally for the conveyance of ice-water which, in this case, meets the oleomargarine just as it issues from the churn. On the left is shown the kneading machine, through which the product is passed previous to packing. The table upon which the product is fed to the hopper has been removed, to bring the cog-wheels into view, through which the oleomargarine is passed.

The following tables are quoted from the report of the Commissioner of Internal Revenue for 1887. They contain the principal statistical data relative to the manufacture and sale of oleomargarine in the United States for the fiscal year ending June 30, 1887: —

Table I. contains a summary of the quantity produced.

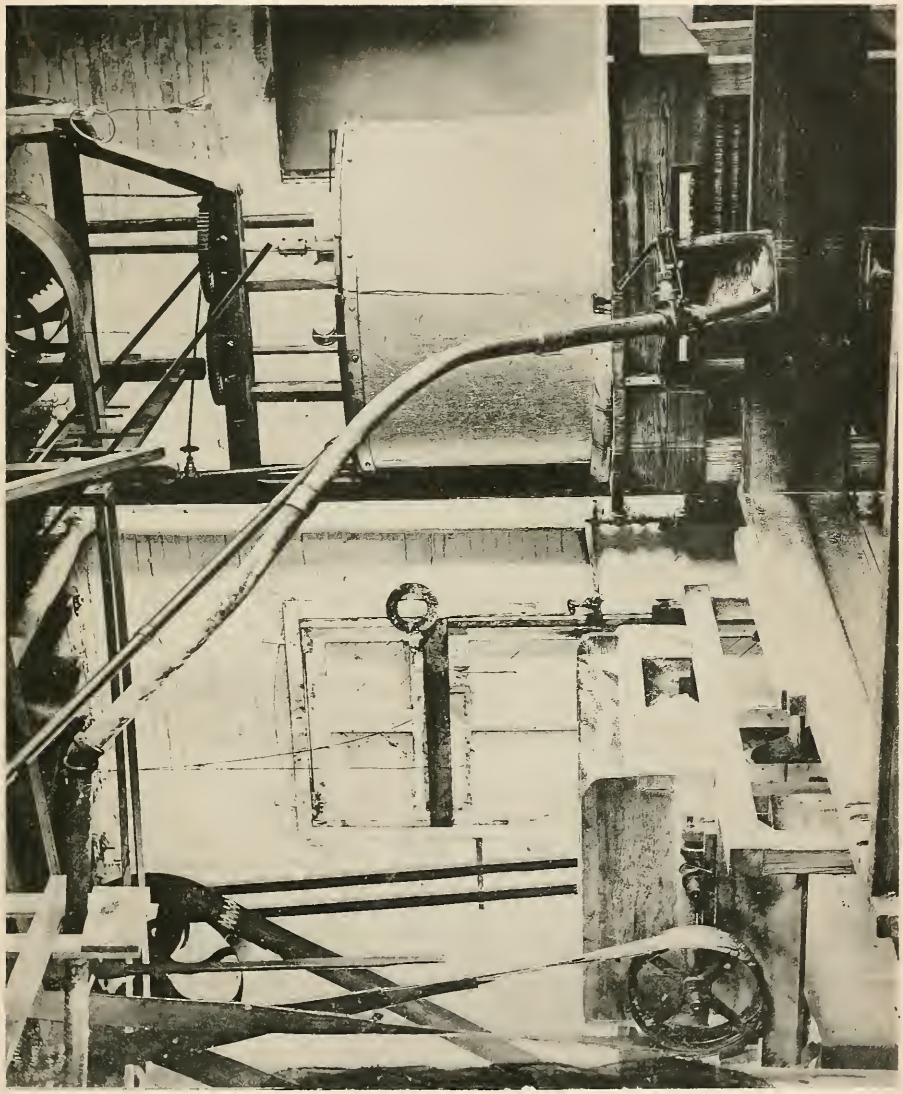
Table II. presents the number of manufacturers, wholesale and retail dealers licensed during the first six months under the operation of the national law, and also for the last two months of the fractional year ending June 30, 1887. Believing that a reasonable estimate of the relative consumption might be obtained by comparing the number of retail dealers with the population, we have introduced another column in which is given the ratio of retail dealers per thousand of the population at the close of the fiscal year (1886-1887). The basis of computation is the population by Census of 1880.

PLATE IV.



PRESS FOR SEPARATING OLEO-OIL FROM STEARINE.

PLATE V.



CHURN AND KNEADING-MACHINE.

If it may be assumed that the consumption per capita bears a tolerably direct relation to these figures, it would appear that Rhode Island held the first position in the scale, Montana second, Massachusetts third, New Mexico fourth, Illinois fifth, Connecticut sixth, Michigan seventh, Colorado eighth, and New Hampshire ninth.

Several States in which oleomargarine was sold during the first part of the year have disappeared from the list, the sale of this article in those States having been abandoned.

In Table III. are presented the data relative to the revenue derived from the manufacture and sale of oleomargarine in each State and territory. As in Table II. the names of several States and territories do not appear in the list.

In Table IV. is presented the percentage of receipts from each State, as compared with the total revenue.

Table V. presents the statistics relative to oleomargarine exported from the United States in 1884, 1885 and 1886. By this table it appears that more than nine-tenths of the exported material was in the form of the crude oil, and that by far the largest purchaser was Holland, where the oleo-oil was received for further manufacture into oleomargarine, mainly at the port of Rotterdam.

TABLE I.

Summary of operations at Oleomargarine factories in the United States from November 1, 1886, to June 30, 1887.

		Pounds.
Stock on hand Nov. 1, 1886,		181,090
Produced from Nov. 1, 1886, to June 30, 1887,		21,513,537
Total,		21,694,627
	Pounds.	Pounds.
Oleomargarine withdrawn from factories, tax paid,	20,743,569	
Oleomargarine lost or destroyed in factories,	51,227	
Withdrawn from factories for export and accounted for,	667,831	
		21,462,627
Removed for export not accounted for June 30, 1887,	56,701	
Remaining in factories June 30, 1887,	175,299	
		232,000
Total,		21,694,627

Table II.

Number of Persons paying Special Taxes as Manufacturers and Dealers in Oleomargarine.

States.	Manufacturers.		Wholesale Dealers.		Retail Dealers.		Ratio of Retail Dealers June 30, '87, to Population.
	Oct. 31, '86, to April 30, '87.	May 1, '87, to June 30, '87.	Oct. 31, '86, to April 30, '87.	May 1, '87, to June 30, '87.	Oct. 31, '86, to April 30, '87.	May 1, '87, to June 30, '87.	
Alabama,	–	–	2	1	11	3	.002
Arkansas,	–	–	6	2	67	20	.025
Colorado,	2	1	12	1	86	11	.057
Connecticut,	–	1	6	2	151	66	.106
Delaware,	–	–	–	–	20	2	.014
Florida,	–	–	1	–	10	–	–
Georgia,	–	–	1	–	12	4	.003
Illinois,	11	7	34	11	735	351	.114
Indiana,	1	1	1	–	46	10	.005
Iowa,	–	–	1	–	1	–	–
Kansas,	2	2	4	1	135	36	.036
Kentucky,	–	–	5	3	127	60	036
Louisiana,	–	–	5	1	19	1	.001
Maine,	–	–	1	–	9	5	.008
Maryland,	–	–	2	–	29	12	.013
Massachusetts,	1	1	46	16	*3.079	247	.139
Michigan,	–	–	21	7	334	123	.075
Minnesota,	–	–	3	–	4	–	–
Mississippi,	–	–	–	–	5	–	–
Missouri,	–	–	6	5	173	55	.025
Montana,	–	–	10	3	34	9	.231
Nebraska,	–	–	4	2	41	5	.011
Nevada,	–	–	2	1	–	–	–
New Hampshire,	–	–	1	–	24	15	.043
New Jersey,	–	–	5	2	174	12	.011
New Mexico,	–	–	5	1	33	15	.126
New York,	6	1	18	–	254	13	.003
North Carolina,	–	–	–	–	2	–	–
Ohio,	4	1	12	1	272	109	.034
Pennsylvania,	5	3	25	–	512	42	.01
Rhode Island,	5	4	18	6	401	208	.754
Tennessee,	–	–	10	2	56	16	.01
Texas,	–	–	9	3	32	6	.003
Virginia,	–	–	1	–	19	2	.001
West Virginia,	–	–	–	–	7	4	.006
Wisconsin,	–	–	11	3	60	26	.019
Total,	37	22	288	74	6,977	1,488	.0296

* By official returns obtained at the office of the Internal Revenue Collector at Boston it appears that this number is not correct. The number actually licensed from Oct. 31, 1886, to April 30, 1887, was only 41, instead of 3,079.

Table III.

The following table gives the amount of Revenue received from the Taxes on Oleomargarine for the year ending June 30, 1887.

STATES.	From tax of 2 cts. per pound.	From Manufacturers.	Retail Dealers.	Wholesale Dealers.	Total.
Alabama, . .	$8 88	-	$368 00	$960 00	$1,336 88
Arkansas, . .	48 46	-	2,430 00	2,720 00	5,198 46
Colorado, . .	7,470 42	$1,600 00	2,388 00	3,160.00	14,618 42
Connecticut, . .	3,801 54	600 00	6,440 00	2,280 00	13,121 54
Delaware, . .	57 66	-	592 00	-	649 66
Florida, . .	2 00	-	188 00	240 00	430 00
Georgia, . .	40 44	-	412 00	240 00	692 44
Illinois, . . .	211,293 04	9,700 00	32,084 00	12,980 00	266,057 04
Indiana, . .	55,057 50	1,100 00	1,924 00	240 00	57,221 50
Iowa, . . .	-	-	24 00	240 00	264 00
Kansas, . .	25,727 80	2,200 00	3,964 00	680 00	32,571 80
Kentucky, . .	70 16	-	5,004 00	2,520 00	7,594 16
Louisiana, . .	19 40	-	482 00	1,680 00	2,181 40
Maine, . . .	-	-	408 00	80 00	488 00
Maryland, . .	47 70	-	1,152 00	480 00	1,679 70
Massachusetts, .	13,474 70	1,100 00	20,392 00	18,720 00	53,686 70
Michigan, . .	1,864 38	-	10,946 00	8,400 00	21,210 38
Minnesota, . .	54 62	-	76 00	720 00	850 62
Mississippi, . .	-	-	108 00	-	108 00
Missouri, . .	49 12	-	3,826 00	3,700 00	7,575 12
Montana, . .	392 32	-	980 00	3,120 00	4,492 32
Nebraska, . .	65 14	-	1,068 00	1,800 00	2,933 14
Nevada, . .	-	-	76.00	920 00	996 00
New Hampshire, .	20	-	1,178 00	160 00	1,358 20
New Jersey, . .	135 02	-	4,684 00	1,440 00	6,259 02
New Mexico, .	122 56	-	1,414 00	1,520 00	3,056 56
New York, . .	36,063 76	3,600 00	6,320 00	4,560 00	50,543 76
North Carolina, .	-	-	44 00	-	44 00
Ohio, . . .	13,655 56	2,600 00	9,770 00	3,680 00	29,705 56
Pennsylvania, .	10,063 06	4,300 00	15,078 00	5,880 00	35,321 06
Rhode Island, .	55,987 36	4,900 00	15,868 00	7,520 00	84,275 36
Tennessee, . .	-	-	2,024 00	3,080 00	5,104 00
Texas, . . .	176 16	-	1,040 00	3,240 00	4,456 16
Virginia, . .	67 34	-	422 00	240 00	729 34
West Virginia, .	52 00	-	260 00	-	312 00
Wisconsin, . .	55 74	-	2,390 00	4,200 00	6,645 74
Total, . .	$135,924 04	$31,700 00	$154,924 00	$101,400 00	$723,948 04

TABLE IV.

Percentage of Receipts,— Oleomargarine, 1887.

Alabama,	.1847	Montana,	.6205
Arizona,	–	Nebraska,	.4052
Arkansas,	.7181	Nevada,	.1376
California,	–	New Hampshire,	.1849
Colorado,	2.0193	New Jersey,	.8646
Connecticut,	1.8125	New Mexico,	.4222
Dakota,	–	New York,	6.9817
Delaware,	.0897	North Carolina,	.0061
District of Columbia,	–	Ohio,	4.1033
Florida,	.0594	Oregon,	–
Georgia,	.0956	Pennsylvania,	4.8789
Idaho,	–	Rhode Island,	11.6411
Illinois,	36.7508	South Carolina,	–
Indiana,	7.9317	Tennessee,	.7050
Iowa,	.0365	Texas,	.6155
Kansas,	4.4992	Utah,	–
Kentucky,	1.0490	Vermont,	–
Louisiana,	.3013	Virginia,	.1007
Maine,	.0674	Washington,	–
Maryland,	.2320	West Virginia,	.0431
Massachusetts,	7.4158	Wisconsin,	.9180
Michigan,	2.9298	Wyoming,	–
Minnesota,	.1175		
Mississippi,	.0149		100.0000
Missouri,	1.0464		

TABLE V.

Oleomargarine Exported from the United States in 1884, 1885 and 1886 (years ending June 30).

COUNTRIES TO WHICH EXPORTED.	1884.			1885.			1886.		
	Imitation Butter.	Oleo Oil.	Total.	Imitation Butter.	Oleo Oil.	Total.	Imitation Butter.	Oleo Oil.	Total.
	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.
Sweden and Norway,	–	–	–	–	–	–	–	27,131	27,131
Denmark,	–	32,644	32,644	–	2,211	2,211	–	5,854	5,854
Germany,	30,790	96,551	127,341	805	8,506	9,311	1,692	976,734	978,426
Holland,	–	33,173,819	33,173,819	10,342	34,012,807	34,023,149	171,826	25,562,417	25,734,343
Belgium,	1,530	2,864,263	2,865,783	–	2,328,777	2,328,777	–	726,690	726,690
England,	96,898	1,545,947	1,642,845	1,192	702,628	703,820	27,565	140,950	168,518
Scotland,	324,418	–	324,418	103,096	–	103,096	106,711	231,458	338,169
Ireland,	–	–	–	–	12,755	12,755	–	–	–
Other European countries,	–	–	–	1,450	–	1,450	–	3,900	3,900
Total,*	1,537,682	37,785,159	39,322,841	761,938	37,120,217	37,882,155	928,053	27,729,885	28,657,938
Canada,	91,876	–	91,876	4,512	–	4,512	38,564	–	38,564
Newfoundland and Labrador,	909,927	60,566	970,493	627,053	39,866	666,919	554,842	54,045	608,887

* Including exports to Canada, Newfoundland and Labrador.

3. Protection Afforded by Existing Laws.

At present the protection afforded in Massachusetts relative to the sale of oleomargarine and other imitations of butter is due to the existence of three different statutes, and of three corps of officials charged with the duty of enforcing such statutes. These are as follows: —

(*a*). The *United States Law* of 1886. The internal revenue collector of the district is charged with the enforcement of this law. The law was quoted in full in the eighteenth report of the State Board of Health (page 94).

(*b*). The *Food and Drug Acts* enacted by the General Court in 1882 and 1884. (Chapter 263 of the Acts of 1882, and chapter 289 of the Acts of 1884.) The enforcement of these laws is intrusted to the State Board of Health, which is also authorized to appoint officers for the purpose of carrying out the intent of the statutes.

(*c*). The *Local Inspection Laws*, included in chapter 56 of the Public Statutes, whereby cities are required, and towns permitted, to appoint local inspectors to enforce the provisions of the law relative to imitation butter.

(a). The National Law of 1886.

Since the order requires the Board to report as to the question of compliance with the laws, without specifying what laws are intended, it is presumed that the General Court had reference to the State laws which were enacted by itself. Brief reference only will be made, therefore, to the effect of the internal revenue laws upon the sale of oleomargarine in Massachusetts.

From evidence presented by the inspectors of the State Board, and also by local inspectors of cities and towns, there is found to have been a very decided limitation of the sale of oleomargarine since the United States law went into effect. This law was enacted August 2, 1886, and became effective on the first of the following November.

The internal revenue collector of Massachusetts has courteously offered such information as would further the object of this inquiry.

During the first six months after the enactment of the

United States law, and before the retail dealers had become fully aware of its provisions, the inspection made by the Board in different parts of the State showed a considerable degree of limitation in the sale of oleomargarine, but not to such an extent as was manifest after the middle of the following year. The number of prosecutions made by this Board for fraudulent sales between Nov. 1, 1886, and June 1, 1887, was about the same as for the first six months of 1886. But from the first of June, 1887, to the present time such sales have very greatly diminished. The effect of a license tax of $480 per year from wholesale dealers and $48 per year from retail dealers has been to limit the sale to a comparatively small number of dealers.

At the time of writing this report the whole number of persons licensed to manufacture and sell oleomargarine in Massachusetts was as follows: —

Licensed Manufacturer.

Cambridge,	1

Licensed Wholesale Dealers.

Boston,	30	Lawrence,	2
Fall River,	1	Springfield,	1
Lowell,	3	Worcester,	3
Salem,	1		–
New Bedford,	2	Total,	45
Gloucester,	2		

Location and Number of Licensed Retail Oleomargarine Dealers, Feb. 15, 1888.

Boston,	107	Chelsea,	3
Fall River,	33	Chicopee,	3
Worcester,	20	Clinton,	3
Salem,	17	Framingham,	3
New Bedford,	14	Gardner,	3
Somerville,	14	Gloucester,	3
Lawrence,	12	Hyde Park,	3
Lowell,	12	Peabody,	3
Cambridge,	11	Sutton,	3
Taunton,	8	Webster,	3
Holyoke,	7	Falmouth,	2
Attleborough,	5	Fitchburg,	2
Haverhill,	5	Ipswich,	2
Lynn,	5	Marlborough,	2
Woburn,	5	Millbury,	2

Blackstone,	2	Hingham,	1
Newburyport,	2	Ludlow,	1
Palmer,	2	Malden,	1
Quincy,	2	Marblehead,	1
Spencer,	2	Medford,	1
Springfield,	2	North Adams,	1
Waltham,	2	Northbridge,	1
Warren,	2	Pittsfield,	1
West Boylston,	2	Revere,	1
Adams,	1	Rockland,	1
Amesbury,	1	Rutland,	1
Ayer,	1	Seekonk,	1
Beverly,	1	Somerset,	1
Braintree,	1	Uxbridge,	1
Bridgewater,	1	Ware,	1
Bristol,	1	Wenham,	1
Brockton,	1	Westborough,	1
Danvers,	1	Westport,	1
Douglas,	1	West Springfield,	1
Franklin,	1	Winthrop,	1
Grafton,	1		
Hampden,	1	Total,*	366

As compared with the population, the retail dealers appear to be unequally distributed, Fall River having a greater number than either Worcester, Lowell or Cambridge, these latter having a larger population. Springfield, Newburyport, Waltham and Fitchburg, each has less than some of the comparatively small towns, and a few cities and larger towns, as Newton, Northampton, Natick and others, have none.

As to Fall River, the following statement was made before the Committee on Agriculture and Forestry of the United States Senate, in June, 1886 : —

Fall River has a population of about 60,000, of which number 17,000 are cotton factory operatives, who with their families number 35,000 to 40,000 persons (two-thirds of the population). These people consume oleomargarine almost exclusively. The goods are sold in ten-pound tubs, with the full knowledge on the part of the consumers of their character. They are all marked and sold in accordance with the Massachusetts law.

From the report of the Commissioner the following statements are quoted with reference to the action of the national law : —

* This number had increased to 395, March 23, 1888.

I am of the opinion that the United States oleomargarine law when passed was intended to be regulatory rather than prohibitory. The bill when introduced was probably intended to be prohibitory, but the reduction of the tax to two cents per pound rendered it possible for the manufacturers to continue the business, except where, as in New York and Pennsylvania, the State law is prohibitory.

The Commissioner, after making recommendations as to the further reduction of taxes upon oleomargarine, and as to the proper marking of packages, further states : —

The experience of this office shows that evasions of the regulation requirements as to marking packages are committed much more frequently by retail dealers than by manufacturers. It is therefore deemed advisable to encourage the sale by retail dealers of manufacturers' packages. On the other hand, it is desirable to avoid discriminating against wholesale dealers who are required to keep books and make returns of sales. In order to encourage the sale of manufacturers' packages by retailers, without detriment to wholesale dealers, the Commissioner recommends further modifications of the law of 1886.

With reference to the effect of the national law upon the production and sale of oleomargarine the following statement is quoted from a recent publication issued by the Garden City Dairy Company of Chicago, Ill. : —

We estimate that the production of oleomargarine has been diminished since November 1. . . . The diminution in the production of oleomargarine has been caused mainly by legal obstacles in the way of its distribution. The sale of oleomargarine has been so obstructed by legislative enactments, State and national, avowedly intended to be prohibitory, that the business has been cut down to forty per cent. of its former volume. The legislation in two States — viz. : New York and Pennsylvania — has been particularly effective in destroying the oleomargarine business. . . . The most important cause of the diminished production was the excessive retail license tax.

The effect of the retail license has been paralyzing.

We have obtained reliable figures to prove that, of the retailers who sold oleomargarine prior to the enforcement of this law, ninety per cent. dropped the business Nov. 1, 1886, and careful estimates show that five per cent. dropped away since May 1, 1887.

Another marked effect of the national law, as shown by the observations of the analysts of the State Board,* has been to diminish very largely the various mixtures of oleomargarine with butter, which were quite generally made in different States, although on a limited scale, as compared with the work of the larger establishments in which oleomargarine containing but a small percentage of genuine butter was made.

In proof of the inability of the ordinary consumer to judge of the difference between butter and oleomargarine, the experience of the chemist and microscopist of the Internal Revenue Department at Washington is worthy of notice. Under the provisions of the national law (section 14) they examine such samples as are submitted to them in contested cases. The number of samples submitted from different parts of the United States was one hundred and thirty-one, and out of this number only twenty-one proved to be oleomargarine, the remainder being butter. Seventy-five, or more than one-half of the number, were sent from Missouri.

(*b*). *Inspection by the State Board of Health.*

The action of the State Board with reference to the sale of oleomargarine has been taken under the provisions of the Food and Drug Acts of 1882 and 1884. These laws forbid the adulteration of food and drugs, and specify very definitely the different forms of adulteration which shall be recognized. It is also provided that the State Board of Health shall take cognizance of such matters and make such investigations as are necessary. Authority is also conferred upon the Board to appoint inspectors and analysts for the purpose of carrying out such inquiry. An appropriation is annually made for executing the provisions of the acts, and it is also required that not less than three-fifths of the sum appropriated shall be expended in enforcing the laws against the adulteration of *milk and milk products*.

An important section of the law is that which provides for the sale of such *mixtures* or *compounds* as are not in-

* Nineteenth Report of State Board of Health, 1887, page 159.

jurious to health and are properly labelled as mixtures or compounds. By the same acts the Board is directed to report its doings annually to the Legislature, such report to include a statement of the number of prosecutions made, and an account of expenditures under the provisions of the act.

For the information of those who are not familiar with these general acts the statute is herewith quoted in full: —

Food and Drugs.

1. No person shall, within this Commonwealth, manufacture for sale, offer for sale, or sell any drug or article of food which is adulterated within the meaning of this act.

2. The term "drug" as used in this act shall include all medicines for internal or external use, antiseptics, disinfectants and cosmetics. The term "food" as used herein shall include confectionery, condiments and all articles used for food or drink by man.

3. An article shall be deemed to be adulterated within the meaning of this act, —

(*a*). In the case of drugs, — (1.) If, when sold under or by a name recognized in the United States Pharmacopœia, it differs from the standard of strength, quality or purity laid down therein, unless the order calls for an article inferior to such standard, or unless such difference is made known or so appears to the purchaser at the time of such sale; (2.) If, when sold under or by a name not recognized in the United States Pharmacopœia, but which is found in some other pharmacopœia, or other standard work on *materia medica*, it differs materially from the standard of strength, quality or purity laid down in such work; (3.) If its strength or purity falls below the professed standard under which it is sold:

(*b*.) In the case of food, — (1.) If any substance or substances have been mixed with it so as to reduce, or lower, or injuriously affect its quality or strength; (2.) If any inferior or cheaper substance or substances have been substituted wholly or in part for it; (3.) If any valuable constituent has been wholly or in part abstracted from it; (4.) If it is an imitation of, or is sold under the name of, another article; (5.) If it consists wholly or in part of a diseased or decomposed, putrid or rotten animal or vegetable substance, whether manufactured or not, or, in the case of milk, if it is the produce of a diseased animal; (6.) If it is colored, coated, polished or powdered, whereby damage is concealed, or if it is made to appear better or of greater value than it really is; (7.)

If it contains any added poisonous ingredient, or any ingredient which may render it injurious to the health of a person consuming it.

4. The provisions of this act shall not apply to mixtures or compounds recognized as ordinary articles of food or drinks, provided that the same are not injurious to health, and are distinctly labelled as mixtures or compounds. And no prosecutions shall at any time be maintained under said act concerning any drug the standard of strength or purity whereof has been raised since the issue of the last edition of the United States Pharmacopœia, unless and until such change of standard has been published throughout the Commonwealth.

5. The State Board of Health shall take cognizance of the interests of the public health relating to the sale of drugs and food and the adulteration of the same, and shall make all necessary investigations and inquiries in reference thereto, and for these purposes may appoint inspectors, analysts and chemists, who shall be subject to its supervision and removal.

Within thirty days after the passage of this act the said Board shall adopt such measures as it may deem necessary to facilitate the enforcement hereof, and shall prepare rules and regulations with regard to the proper methods of collecting and examining drugs and articles of food. Said Board may expend annually an amount not exceeding ten thousand dollars for the purpose of carrying out the provisions of this act: *provided, however*, that not less than three-fifths of said amount shall be annually expended for the enforcement of the laws against the adulteration of milk and milk products.

6. Every person offering or exposing for sale, or delivering to a purchaser, any drug or article of food included in the provisions of this act, shall furnish to any analyst or other officer or agent appointed hereunder, who shall apply to him for the purpose and shall tender him the value of the same, a sample sufficient for the purpose of analysis of any such drug or article of food which is in his possession.

7. Whoever hinders, obstructs, or in any way interferes with any inspector, analyst, or other officer appointed hereunder, in the performance of his duty, and whoever violates any of the provisions of this act, shall be punished by a fine not exceeding fifty dollars for the first offence, and not exceeding one hundred dollars for each subsequent offence.

8. The State Board of Health shall report annually to the Legislature the number of prosecutions made under said chapter, and an itemized account of all money expended in carrying out the provisions thereof.

9. An inspector appointed under the provisions of said chapter two hundred and sixty-three of the acts of the year eighteen hundred and eighty-two shall have the same powers and authority conferred upon a city or town inspector by section two of chapter fifty-seven of the Public Statutes.

10. Nothing contained in chapter two hundred and sixty-three of the acts of the year eighteen hundred and eighty-two shall be in any way construed as repealing or amending anything contained in chapter fifty-seven of the Public Statutes.

11. Before commencing the analysis of any sample the person making the same shall reserve a portion which shall be sealed; and in case of a complaint against any person the reserved portion of the sample alleged to be adulterated shall upon application be delivered to the defendant or his attorney.

While the inspectors of the State Board of Health have acted under the general authority conferred by the statutes of 1882, chapter 263, they have also usually acted in the cases of butter prosecutions under the provisions of the local inspection laws, by reason of authority conferred by an act of 1885, granting such authority. (Chapter 352, Acts of 1885.)

Under the provisions of the foregoing act, this Board and its predecessor, the Board of Health, Lunacy and Charity, have annually presented to the Legislature a report of their transactions, beginning with the report of 1883. The work of the first year was mainly that of inquiry, to ascertain the actual condition of the food and drug supply of the State, as preliminary and essential to a more administrative or executive line of work. Another reason for the limited character of the work of the first year may be found in the fact that the appropriation of that year was sufficient only for analytical work. In subsequent years the appropriation was increased sufficiently to allow the appointment of inspectors and the execution of the law to its fullest extent.

With reference to that portion of the work which relates to oleomargarine the following summary is compiled from the reports of the Board already quoted. This summary contains the chemists' reports upon such samples of butter as were submitted to them by the inspectors: —

The highest percentage of water found in any sample was 12.16. The percentages of insoluble fatty acids found in the pure fat of

each sample will be found in the accompanying tables. The highest limit of insoluble fatty acids in genuine butter fat — 90 per cent. — has been taken as the dividing line between the genuine and the artificial product. Since the samples of real butter which reached this limit are comparatively rare, and since many specimens of imitation butter will fall below the 90 per cent., it is probable that more or less of the samples in the table, which come very near the line, might be justly designated as spurious.

Date.	Inspector's Number.	Price per Pound.	Per cent. Insol. Fatty Acids.	Remarks.
Feb. 9, 1884,	233	–	89.43	
March 6, 1884,	274	$0.38	95.95	Adulterated.
6, 1884,	275	.35	93.83	Adulterated.
6, 1884,	276	.35	89.38	
6, 1884,	277	.32	88.04	
6, 1884,	278	.28	88.34	
6, 1884,	279	.35	86.55	Sample contained 12.16 per cent. water.
6, 1884,	280	.28	87.43	
6, 1884,	281	.35	88.44	
6, 1884,	282	.35	88.57	
6, 1884,	283	.25	88.92	
24, 1884,	285	.25	95.42	Contained considerable lard
24, 1884,	286	.25	88 89	
April 15, 1884,	288	.40	88.76	
15, 1884,	289	.30	88 81	
15, 1884,	290	.37	89.38	
15, 1884,	291	.36	89.60	
15, 1884,	292	.30	88.79	
15, 1884,	293	.38	88.31	
15, 1884,	294	.36	88.37	
1884,	295	.36	88.71	
1884,	296	.35	87.47	
1884,	297	.35	89.41	
June 1884,	321	.36	88 09	
1884,	322	28	89.17	
1884,	323	.34	88.32	
1884,	324	.34	87.19	
1884,	325	.34	86.41	
1884,	326	.38	87.69	
1884,	327	.30	88.23	
Nov. 1884,	482	.22	90 46	Adulterated.
1884,	483	–	92.19	Adulterated.
1884,	484	–	87.42	
1884,	485	.25	91.30	Adulterated.
1884,	512	.28	94.14	Adulterated.
1884,	595	.30	89.00	
1884,	596	.25	94.06	Adulterated.
1884,	597	.25	87 63	
Dec. 1884,	616	.25	93.02	Adulterated.
1884,	617	.20	92.62	Adulterated.
Oct. 1884,	1245	–	87.83	
1884,	1246	–	88.13	
1884,	1251	–	86.29	
Nov. 1884,	1289	–	87.45	
1884,	1290	–	92.82	Adulterated.
1884,	1292	–	87.66	
1884,	1294	–	85.63	
Dec. 1884,	1345	–	94.33	Adulterated.
Jan. 1885,	1911	–	94.24	Adulterated.

DATE.	INSPECTOR'S NUMBER.	Percentage of Insoluble Fat Acids.	Amt. Decinormal Sodic Hydrate for Sol. Fat Acids from 2.5 Gm.	REMARKS.
Feb. '85,	1602	86.20	-	
"	1604	-	-	Sold as oleomargarine, but wrapper not marked.
"	1606	87.49	-	
"	1608	86 21	-	
"	1820	93.46	-	Adulterated.
Mar. '85,	1956	95.13	-	Adulterated.
"	1958	86.00	-	
"	1960	86.31	-	
"	1962	88.11	-	
"	1964	87.41	-	
"	1966	94.40	-	Adulterated.
"	2356	87.94	-	
"	2470	86.54	-	
"	2474	88.23	-	
"	2476	93.76	-	Adulterated.
April, '85,	2524	94.45	-	Adulterated.
"	2626	89.15	-	
"	2628	88.11	-	
Feb. '85,	2647	93.50	-	Adulterated.
May, '85,	2818	-	-	Sold as oleomargarine, but wrapper not marked.
June, '85,	2984	87.75	-	
July, '85,	3340	86.55	-	
Oct. '85,	3906	88.96	-	
"	3908	85.74	13.7 c.c.	
"	3956	93.64	3.0	Adulterated.
"	3958	87.20	-	
"	3960	91.08	11.6	"Lily of the Valley"—acknowl'g'd to be adulterated.
"	3962	94.24	3.0	
"	5036	-	9.1	Adulterated.
"	5056	-	11.6	Adulterated.
May, '86,	5114	-	14.5	
"	5116	-	10.8	Adulterated.
Nov. '85,	5514	-	1.4	Adulterated.
"	5516	-	4.2	Adulterated.
Aug. '85,	5517	-	-	Sold as oleomargarine, but wrapper not marked.
"	5525	-	14 0	
Sept. '85,	5769	87.23	-	
"	5771	87.13	-	
"	5893	94.90	-	Adulterated.
"	5899	86.67	13.0	
Jan. '86,	5902	-	13.0	
"	6034	-	14.1	
"	6044	-	11.5	Adulterated.
"	6132	-	12.8	
Feb. '86,	6248	-	2.0	Adulterated.
Oct. '85,	6249	-	8.6	Adulterated.
"	6251	87.66	-	
"	6253	95.07	-	Adulterated.
Feb. '86,	6300	-	11.5	Acknowledged to be a mixture.
"	6334	-	15.5	
"	6340	-	4.0	Adulterated.
"	6342	-	12.4	
"	6344	-	13.8	
"	6348	-	14.1	
"	6350	-	12.4	
April, '86,	6468	-	1.6	Adulterated.
May, '86,	6864	-	1 8	Adulterated.
Nov. '85,	6865	-	14.4	
"	6867	-	-	Sold as butterine, but wrapper not marked.

Date.	Inspector's Number.	Percentage of Insoluble Fat Acids.	Amt. Decinormal Sodic Hydrate for Sol. Fat Acids from 2.5 Gm.	Remarks.
Nov. '85,	6869	–	1.4	Adulterated.
"	6879	–	13.6	
"	6881	–	13.0	
"	6883	–	9.6	Adulterated.
"	6889	–	–	Sold as butterine, but wrapper not marked.
"	6891	–	2.5	Adulterated.
May, '86,	6914	–	2 2	Adulterated.
"	6916	–	2.0	Adulterated.
"	6944	–	1.5	Sold as oleomargarine.
Feb. '86,	7127	–	2 0	Adulterated.
"	7375	–	13.0	
"	7465	–	13.1	
"	7469	–	4 0	Adulterated.
"	7513	–	12.9	
"	7535	–	13.0	
"	7547	–	2.0	Adulterated
"	7709	–	5.5	Sold as pure, but wrapper marked "butterine."
"	7715	–	15.0	
"	7721	–	5 0	Adulterated.
April, '86,	7803	–	14.3	
"	7805	–	15.0	
"	7813	–	13 4	
"	7935	–	15.2	
"	8097	–	12.6	
May, '86,	8353	–	15.8	
April, '85,	A—	87.83	–	
"	B—	86.75	–	Taken from the churn.
Jan. '86,	C—	–	7.6	
Feb. '86,	D—	–	13.5	

The number of samples collected from different parts of the State, and examined by the officers of the Board previous to Oct. 1, 1886 (most of which are detailed in the foregoing table), was one hundred and seventy-five, of which number, fifty-nine, or 33.7 per cent., were found to be oleomargarine.

In addition to these samples included in the foregoing summary there have also been examined by the analysts of the Board, from Oct. 1, 1886, to Feb. 1, 1888, one hundred and seventy-three samples, of which number forty-four, or 25.4 per cent., were found to be oleomargarine.

Of those which have been examined since Feb. 1, 1888, in aid of the present inquiry, more will be said on a later page of this report.

Prosecutions.—The number of prosecutions conducted under the provisions of the acts relative to food and drug inspection, for fraudulent sales of oleomargarine as butter, or for other violations of those provisions which relate to

this article of food, up to March 30, 1888, has been 57. These were distributed as follows: —

In Boston,	8	In Marlborough,	2
Lowell,	11	Somerville,	1
Cambridge,	3	Fitchburg,	1
Springfield,	6	Lynn,	1
Worcester,	9	Lawrence,	1
Fall River,	5	Holyoke,	1
Salem,	3	Warren,	1
Chicopee,	2		—
Ware,	2	Total,	57

This number represents the number of parties prosecuted, and not the number of complaints entered. In many cases several complaints were made against one individual for violation of different provisions of the statutes.

The date of these prosecutions was as follows: —

In 1884, June,		1	In 1886, October,	3	
In 1885, January,	5		December,	1	
February,	2				—15
May,	4		In 1887, January,	2	
October,	1		February,	2	
November,	3		April,	2	
December,	8		May,	3	
		—23			— 9
In 1886, January,	1		In 1888, February,	8	
February,	2		March,	1	
March,	3				— 9
May,	2				—
June,	1		Total,		57
August,	2				

These prosecutions with three exceptions resulted in conviction, and have had a marked effect in restricting the sale of oleomargarine to its proper limits under the law. Undoubtedly the action of the national law has also had a marked effect in the same direction during the past year; the two laws operating together thus afforded a double protection against fraud.

Complaints in these cases have been distributed quite uniformly over the State in sixteen cities and towns, and these prosecutions constitute about one-fifth of all which have been entered by the State Board under the provisions of the Food and Drug Acts.

Some of the cases enumerated in this list presented peculiar features worthy of notice. Six complaints were entered against one firm for persistent violation of the statutes, and convictions were obtained in each instance. In two cases complaints were entered for obstructing an inspector.

In one case the following remarkable evidence was presented by the defendant The butter had been conclusively shown, on the evidence of a competent chemist, to have been adulterated with oleomargarine. A woman was introduced by the defendant who testified that she had made the butter in question from pure milk. A so-called " bovine " expert was also introduced, who testified that the cow who produced the milk from which the butter was made was very lean in consequence of impoverished feeding, and also that the fat usually found upon the ribs of such an animal had become absorbed into the milk, and hence the chemist found genuine beef-fat in the butter, alleged to have been thus produced by a natural process. It is none the less a remarkable fact that this testimony was accepted and the defendant discharged.

Nearly all of these prosecutions were made on account of retail sales, in which the provisions relative to proper marking of packages were violated. In several cases the defendants appealed, but afterwards paid the fines which were imposed, before the cases could again come to trial.

Methods in which the Statutes relative to the sale of Oleomargarine have been evaded. — During the first years after the enactment of the law the principal forms of violation were those consisting of sales of oleomargarine as butter. It was then quite common to find large signs in provision and butter stores labelled in conspicuous letters, " No Oleomargarine Sold Here." And yet some of these were the first places found to be violating the law, and covertly selling oleomargarine as butter. At a later period the complaints related more commonly to the improper marking of packages and wrappers, or to the want of such marks.

The paper used for wrapping butter in retail packages often presents inducements to fraud. The paper employed is often dark brown wrapping paper of the coarsest quality,

upon which is usually stamped the word "oleomargarine," or "butterine," as the State and national laws require, but being imprinted upon a dark colored paper in some light colored ink, such as green or pink, the mark is not noticed by the purchaser, especially if the purchase is made in the evening, as many laboring men are accustomed to do after the day's work is over. The German regulations offer a good preventive for this difficulty, in requiring that the paper wrapper shall be of a *light color*, and the mark or stamp shall be made in *black ink*.

The method of marking paper, to be used for the purpose of wrapping oleomargarine, in the case of retail sales, deserves notice. At present two marks are required, one by the national and the other by the State law. By the provisions of the former each retail package must be marked as "the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, shall prescribe," and in accordance with the regulations laid down by the Commissioner, it is required that these marks shall state, in letters not less than one-fourth inch square, the quantity contained in the package in pounds, the name and address of the dealer, and the word "oleomargarine."

By the provisions of the State law the words "oleomargarine," "imitation butter," or "butterine," must be stamped in letters not less than one-half inch in length, the style of letter to be plain, uncondensed Gothic.

For the purpose of imprinting these marks upon paper it is customary to use a rubber stamp with an inking-pad. The first impression after applying the ink is quite distinct, but each impression after the first becomes less and less distinct until, after a dozen or more impressions, the mark upon the paper becomes more and more illegible, especially if coarse brown paper is used for wrapping. The experience of the inspectors shows that these illegibly marked wrappers are the sort which are often used by some retail dealers for the wrapping of oleomargarine.

Another mode of deception is offered by turning the stamped portion of the paper inward, the retailer trusting that his customer will not see it. Still another form of fraud consists in using three wrappers, the stamp being im-

printed upon the middle paper only, and thus concealed by the outer and inner papers.

In some cities, and especially in the western part of the State, dealers were found to comply with the national law but not with the State law, and were selling from tubs which were marked upon the top only, in accordance with the national law, and not upon the side and bottom as the Massachusetts law provides.

Another form of deception relates to the case, refrigerator, or cold closet in which the oleomargarine is exposed for sale. This case usually stands behind the counter at some distance from the customers. In it are placed the tubs of butter, laid upon their sides, with the top or butter surface forward and exposed to view. The shelves are of a sufficient depth to allow the tubs to set back several inches from the edge of the shelf. From this mode of procedure it happens that, even if the tub is marked upon the top, side, and bottom according to law, the side and bottom are out of sight of the customer; the cover, too, may be stowed out of sight, or turned top side down, and there is nothing to indicate the character of the article to be sold. It quite frequently happens that the inspector, on entering a retail shop, finds matters in a condition of commotion, the proprietors hurrying about to search for the covers of tubs in order to put them in their proper and conspicuous location, as the provisions of the law would imply.

Singularly enough it happens that a very large proportion of the people who purchase oleomargarine under the impression that they are obtaining butter are actually defrauded in spite of perfectly legal sales of the article in question, since many people take no trouble to examine the wrappers surrounding the packages. Retailers in many places are aware of this habitual heedlessness on the part of the customer and turn it to their own advantage. The inspectors of the Board are quite familiar with this fact, not only from inquiry among consumers, but also of the retailers, some of whom freely acknowledge their own familiarity with this fact, and their readiness to take advantage of it. Again it is true that among the actual purchasers are many people who cannot read, either little children or illiterate adults, of

whom there are very many in our large manufacturing cities and towns, where oleomargarine is chiefly sold. Another similar class comprises the foreigners who may see the label but have no knowledge of its meaning.

In order to carry out this inquiry as to the question of compliance with the laws to its fullest extent, a special agent was employed to canvass the State under more exacting conditions than any which had hitherto been employed. It is quite manifest that in order to obtain a fair estimate of the food supply the inquirer must pursue his operations from the stand-point of the consumer.

Such is ordinary human nature that the trained inspector, who has been in public service for several years, and is consequently known and recognized as such, receives different consideration at the hands of the food-vendor from that which is accorded to the consumer. This is one of the recognized difficulties which attends a constant and long-continued inspection, such as the State of Massachusetts has had for the past four years or more. The inspector when known as such to the vendor, on inquiry for samples of goods, will usually receive those of good quality, while an ordinary customer under like circumstances might often receive articles of an inferior quality. To this rule butter forms no exception.

The special agent referred to was instructed to obtain samples, to the number of two hundred and fifty or more, from dealers in butter in all parts of the State. The article sought for was in all cases to be a cheaper or inferior grade of butter, and in no case was oleomargarine to be called for. Under these circumstances it was believed that if any dealers were violating the law, either as to its exact requirements or as to its spirit, such violations would be most likely to be revealed. The collector was required to familiarize himself with the laws relating to the sale of butter and oleomargarine, and to note any violations of such laws which might come to his notice.

In order that a just estimate might be obtained, the agent employed was required to visit cities and towns in all parts of the State, including places in which licensed

dealers were located, and other towns where there were no licensed dealers.

The following table gives the results of this immediate inquiry. In it are presented the names of places where samples are obtained, the number of such samples, the number found to be genuine butter, the number found to be oleomargarine, and the number stamped "oleomargarine": —

	Number of Samples Collected.	Number Found Genuine.	Number Found to be Oleomargarine.	Number Stamped "Oleomargarine."
Boston, . . .	41	40	1	–
Cambridge, . .	13	13	–	–
Lowell, . . .	15	11	4	3
Worcester, . .	15	13	2	2
Lynn, . . .	15	15	–	–
Lawrence, . . .	15	11	4	1
Fall River, . .	15	13	2	1
Springfield, . .	16	14	2	1
Holyoke, . . .	16	15	1	1
Salem, . . .	10	4	6	1
Gloucester, . .	10	9	1	1
Brockton, . . .	10	9	1	–
Waltham, . . .	10	9	1	–
Fitchburg, . . .	10	10	–	–
Taunton, . . .	8	6	2	–
Newton, . . .	6	6	–	–
Marlborough, . .	5	5	–	–
Peabody, . . .	5	2	3	–
Quincy, . . .	4	4	–	–
Sutton, . . .	3	2	1	1
Blackstone, . .	3	2	1	1
Plymouth, . . .	2	2	–	–
Reading, . . .	2	2	–	–
Lynnfield, . . .	2	2	–	–
Lincoln, . . .	2	2	–	–
Middleton, . . .	2	2	–	–
Halifax, . . .	1	1	–	–
Total, . . .	256	224	32	13

The number found to be stamped "oleomargarine" (13), subtracted from the entire number (32) which proved on analysis to be oleomargarine, leaves 19 as the actual number of fradulent sales under this special inquiry, which is but 7.4 per cent. of the number collected. It would be proper to call a few of these stamped fraudulent sales, since oleomargarine was not called for except in a few instances.

The following statistics are introduced to show the amount of adulteration of butter in other countries as compared with that in Massachusetts.

The reports of the Paris Municipal Laboratory for 1887 give the number of samples examined as 246, of which 40, or 16 per cent., were adulterated. These samples included a few specimens of cheese, since the two articles were not separated in the report. The form of adulteration in the case of butter consisted in the presence of foreign fats, while a few samples had an excess of water.

The following table comprises the statistics of butter analysis in England for the years 1877 to 1886 inclusive, with the percentage of adulteration found in each year:—

ENGLAND. — *Samples of Butter Analyzed by the Public Analysts, 1877–1886.**

Year.	Number of Samples.	Number Adulterated.	Percentage Adulterated.
1877,	916	99	10.8
1878,	904	116	12.6
1879,	1,306	171	13.0
1880,	1,155	211	18.3
1881,	1,353	188	13.9
1882,	1,238	173	13.9
1883,	1,311	236	18.0
1884,	1,832	373	20.4
1885,	2,001	377	18.9
1886,	2,332	401	17.3
Total,	14,338	2,345	16.4
Five Years.			
1877–81,	5,634	785	13.9
1882–86,	8,704	1,560	17.9
London, 1886,	756	132	17.4

(c). *Local Inspection.*

By the provisions of the existing laws of Massachusetts the twenty-three cities are required to appoint inspectors of milk annually, and by further provisions these inspectors are also required to execute the laws relative to the inspection of

* Report of the select committee on the Butter Substitutes Bill, July, 1887.

butter and its substitutes. In the towns this provision is not obligatory, but permissive. We do not find that more than a half dozen towns have made such appointments. In the absence of such an appointment the town clerk has authority to issue licenses to persons selling from carriages or other vehicles and to register the names of persons selling from stores or markets.

Previous to the enactment of the general food act of 1882, but little efficient inspection, either of milk or butter, had been accomplished in any of the cities or towns. The methods of operation were radically defective, and appropriations of no inconsiderable size were undoubtedly wasted in doing practically nothing at all. Chemical analyses of samples were of rare occurrence, and complaints against offenders were still more rare.

In 1883 the investigations of the State Board conclusively demonstrated the existence of serious adulteration in the larger cities, especially in Boston and its immediate vicinity, and showed the necessity of efficient inspection. In Boston such inspection has been very thoroughly maintained from that time to the present. In other cities the want of adequate inspection has undoubtedly been due to the failure on the part of such cities to provide the necessary means for conducting it, and the urgent need of such inspection in some of the populous manufacturing cities of Eastern Massachusetts is still quite apparent.

Several laws and amendments have been enacted by the Legislatures of 1878, 1880, 1881, 1884, 1885 and 1886, relative to the restriction of the sale of adulterated butter, and having reference to local administration. The first act relative to the adulteration of butter passed in Massachusetts was the following law of 1878 : —

CHAP. 106.

AN ACT to prevent Deception in Sales of Butter.

Be it enacted, etc., as follows:

SECTION 1. Every person who shall manufacture for sale, or who shall offer or expose for sale, any article or substance in semblance of butter, not the legitimate product of the dairy, and not made exclusively of milk or cream, but into which the oil or fat

of animals, not produced from milk, enters as a component part, or into which melted butter, or any oil thereof has been introduced to take the place of cream, shall distinctly and durably stamp, brand or mark upon the top and side of every tub, firkin, box or package of such article or substance, the word "oleo-margarine," in letters at least one-half inch in size; and in case of retail sale of such article or substance in parcels, the seller shall in all cases deliver therewith to the purchaser a written or printed label bearing the plainly written or printed word "oleo-margarine;" and every sale of such article or substance not so stamped, branded, marked or labelled, is declared to be unlawful; and no action shall be maintained in any of the courts of this state to recover upon any contract for the sale of any such article or substance not so stamped, branded, marked or labelled.

SECT. 2. Every person who shall knowingly sell, or offer to sell, or expose for sale, or have in his or her possession with intent to sell, contrary to the provisions of this act, any of the said article or substance required by the first section of this act to be stamped, marked or labelled as therein stated, or in case of retail sale without delivery of a label required by the first section of this act, shall for each such offence be punished by a fine of one hundred dollars; and on trial for such offence, proof of the sale, or offer to sell, or of the exposure for sale, shall be presumptive evidence of knowledge of the character of the article so sold, or offered, or exposed, and of knowledge that the same was not marked, branded, stamped or labelled as required by this act.

Approved April 3, 1878.

Further inquiries showed the necessity of certain amendments to this law, and the words "plain Roman letters" were introduced to designate the type to be used for marking. Provision was also made for the use of the terms "adulterated butter," "imitation butter" and "butterine" in marking packages. It was soon found that the words "Roman type" were inefficient to prevent evasion of the law, and such devices as the following became quite common. These are *fac-similes* of stamps in actual use: —

OLEOMARGARINE

Hence the following words were introduced: "*Stamped, labelled, or marked in a straight line in printed letters of plain, uncondensed Gothic type, not less than one-half inch in length, so that said words cannot be easily defaced, upon the top, side and bottom of every tub*," *etc.*

The advantages of a clear and definite provision as to the style of type used for marking is shown in the examples given on page 39, which were also copied from stamps or marks in actual use.

In order to ascertain the character of the work done under the laws relative to local inspection in cities and towns, with reference to oleomargarine, a circular was addressed to the local inspectors in each of the cities and towns in the State having a population over 10,000 inhabitants, and to a few towns of smaller size, with the following inquiries: —

1. How many licensed wholesale dealers in oleomargarine and butterine are at present doing business in your city or town?

2. How many licensed retail dealers in the same products?

3. What amounts of such products are sold each month in your city or town? State approximately, if exact information is not at hand.

OLEO-MARGARINE.

BUTTERINE.

4. What amount of butter is sold per month?

5. What effect have the recent State and national laws had upon their sale?

6. Have you any evidence that these laws are not complied with?

The following question relates to the sanitary aspect of the subject: —

7. Have any instances come to your knowledge of illness of any sort from the use of oleomargarine or butterine, and if you have knowledge or evidence of such instances, please to give the particulars?

To these circulars the following replies were received. The terms "licensed dealers" in the first and second inquiries should be understood as referring to dealers holding licenses under the State laws of Massachusetts. (Acts of 1886, chapter 317, § 4.)

CITY OF BOSTON (POPULATION, 1885, 390,393).

DEPARTMENT OF INSPECTION OF MILK AND VINEGAR,
1151 WASHINGTON STREET, BOSTON, Jan. 3, 1888.

Dr. S. W. ABBOTT, *Secretary of State Board of Health.*

SIR: — In reply to your communication received this day I have to report as follows: —

1. There have been registered at this office during the year 1887 the names of one hundred and twelve dealers in oleomargarine. Several of these were registered previous to May 1, and did not renew at that time and are now out of business. We have at the present time the registrations of one hundred and seven dealers. In addition there are a few who have never taken out a license, against whom complaints are pending or in preparation.

2. Answered as above.

3. We have no data which will enable us to state anything in regard to the quantity of oleomargarine sold in Boston.

4. Same reply as to butter. Refer you to the Boston Produce Exchange.

5. The United States revenue tax law has had the effect of greatly reducing the number of retail dealers. This office registered the names of five hundred and eighty-three dealers in 1886, and, as above stated, only one hundred and twelve in 1887.

The quantity of oleomargarine sold has not, however, decreased; on the contrary, to the best of our knowledge it has increased, the trade being in fewer hands. The State laws have some effect in causing dealers to sell the article for what it is, but in some re-

spects are very imperfect, but may easily be rendered perfectly satisfactory. There is now no law which prevents the sale of oleomargarine as butter; and this is done, in some cases, although the wrappers are plainly marked, the difficulty being that a certain portion of the community who purchase it cannot read.

One of the largest retailers in Boston recently said to me, "The Massachusetts law does not interfere with my trade, I sell it as butter, although I always sell it in marked wrappers. My customers do not notice the mark, or if they do, I tell them that we sell oleomargarine as well as butter, and we mark *all* our papers so that we may not make any mistake and accidentally send it out unmarked. This generally satisfies them, and they come back as regular customers, and we sell it [oleomargarine] to them right along."

Such cases are the exception and not the rule, but they exist in more instances than one. My opinion is that there should be a statute, as in Connecticut, requiring the seller to verbally inform the customer in every instance that the article is not butter but is oleomargarine; also, to make a penalty for selling it as butter. The leading wholesalers and manufacturers will favor any legislation which will ensure the sale of "oleo" for what it is, as they believe it will increase the sale of their goods.

I have no doubt that ninety per cent. of the oleomargarine now sold is sold honestly, but there always will be a certain number who will cheat if they have an opportunity.

6. We have made during the year forty-six complaints against the proprietors or clerks in thirty-three stores. Six of these complaints were for non-registration, and probably six more were cases of carelessness or negligence without criminal intent; the remainder of the cases, being twenty-one stores, were those where the goods were sold as butter (that being called for), and in packages not in compliance with the provisions of the statutes or the goods exposed unmarked.

The forty-six cases were as follows: —

For selling in an unmarked wrapper,	12
selling with wrapper folded inside, so as to conceal the mark with probable fraudulent intent,	12
exposing for sale in tub not marked on top, side or bottom,	10
selling without license,	6
selling with mark covered with outside wrapper with fraudulent intent,	4
exposing for sale not in original package and unmarked as required,	2
Total,	46

As to the sanitary aspect of the subject, I will say that I have yet to meet any unprejudiced person, competent to pronounce an opinion, who believes that these goods are in any way injurious. Interested parties have told more lies about oleomargarine than some of them can ever answer for. I have bought and used oleomargarine, as an experiment, in my family and on my table. It has all the essential qualities of butter except the delicate flavor of new "creamery." I would use it altogether at the present time if butter should advance in price to fifty cents per pound.

Many samples have been, from time to time, brought to this office by persons who have suspicions that somebody has cheated them by selling them oleomargarine; in almost every case the samples have proved to be poor butter; there is much of the latter on the market at all times, but I have never in all my experience met with any poor or rancid oleomargarine. I believe it is an admitted fact that oleomargarine keeps very much better than butter. Much of the former is used on board sea-going vessels on this account. Yours, very respectfully,

JAMES F. BABCOCK,
Inspector of Milk and Vinegar of the City of Boston.

WORCESTER.

POPULATION (Census 1885), 68,389.

1. Two.
2. Nine.
3. Ten tons.
4. Forty tons.
5. Not any.
6. No.
7. Not any.

LOWELL.

POPULATION, 64,107.

1. Two.
2. Four.
3. I cannot say.
4. I cannot say.
5. They complain of high license.
6. No.
7. Do not know of any.

CAMBRIDGE.

POPULATION, 59,658.

1. Thirteen.
2. Six.
3. Cannot say.
4. Cannot say.
5. Fifty-nine licenses were granted in 1886; nineteen in 1887.
6. No.
7. No.

FALL RIVER.

POPULATION, 56,870

1. Two.
2. Sixteen.
3. Sixteen thousand pounds per month.
4. Thirty thousand pounds per month.
5. The laws have been complied with better.
6. No.
7. No.

LYNN.

POPULATION, 45,867.

2. Five.
3. About 5,000 pounds.

4. About 14,000 pounds.
5. I think that the national laws have had a good effect. The sale is now confined to a few places, making it easier to control and enforce the law.
6. I think that the laws are complied with.
7. Not any.

LAWRENCE.

POPULATION, 38,862.

1. One.
2. Seven.
4. The amount used is about eight ounces per week for each person. Lawrence contains some 41,000 persons, which would amount to 25,000 pounds per week; but the amount of substitute butter would have to be deducted.
5. They have driven many out of the business.
6. None.
7. None.

SPRINGFIELD.

POPULATION, 37,575.

1. One.
2. Four.
3. The government licenses are taken for eight months; the estimate of monthly sales for these months is 14,000 pounds per month.
4. Cannot tell, but think six times more than this; say 90,000 pounds.
5. Nearly, if not quite, as much sold.
6. Think at present the law is well complied with.
7. Have no such knowledge.

NEW BEDFORD.

POPULATION, 33,393.

1. None.
2. Eight.
3. Nearly correct—7,000 pounds.
4. About 112,000 pounds.
5. The high national tax has driven many out of business and caused largely decreased sales.
6. None.
7. None at all.

SOMERVILLE.

POPULATION, 29,971.

1. None.
2. Thirteen.
3. Four thousand seven hundred and fifty, as given on application; this is as they approximated their sales.
4. I could not give you even an approximate amount, as a large amount used here is bought in Boston by families.
5. Reduced the number of licenses from twenty to thirteen.
6. None.
7. None.

SALEM.

POPULATION, 28,090.

1. Four.
2. Thirteen.
3. About 7,000 pounds.
4. About 40,000 pounds.
5. Good effect.
6. No.
7. There has not.

HOLYOKE.

POPULATION, 27,895.

1. One.
2. Four.
3. Ten thousand pounds.
4. I have no means of knowing.
5. Greatly reduced it.
6. No.
7. There has been no such instance.

CHELSEA.

POPULATION, 25,709.

1. None.
2. Six.
3. About 600 pounds.
5. Reduced the number of licenses two-thirds.
6. No.
7. No.

TAUNTON.

POPULATION, 23,674.

1. None.
2. Two only have been licensed by me.
3. About 400 pounds.
4. Not less than 20,000 pounds.
5. Lessened it.
6. I have not.
7. No.

HAVERHILL.

POPULATION, 21,795.

1. None.
2. Three.
3. Perhaps 100 pounds.
4. There are about 100 dealers, but they cannot readily give amount of sales; perhaps 500 pounds each per month.
5. Decreased it.
6. None.
7. Not any.

NEWTON.

POPULATION, 19,759.

1. None.
2. Five.
3. Have no information; should estimate a comparatively small amount.
4. Have no data upon which to make estimate; should say large amount.
5. Cannot possibly say.
6. None.
7. None.

MALDEN.

POPULATION, 16,407.

1. None.
2. Nine.
3. Two thousand five hundred pounds.
4. Forty thousand pounds.
6. None.
7. None.

FITCHBURG.

POPULATION, 15,375.

1. None.
2. One, who comes from West Gardner.
3. I have no means of knowing.
4. I have no means of knowing.
5. I should say they had a good effect.
6. I have not.
7. I know of no illness of any sort from the use of these goods.

WALTHAM.

POPULATION, 14,609.

1. None.
2. Seven; five of whom sell from carriages and reside in other towns.
3. About 700 pounds by the two local dealers. I am unable to state how much is sold from the carriages. Many people having large families purchase it in Boston.
4. About 2,300 pounds.
5. About thirty of our grocers dealt in oleomargarine and butterine before the recent national law was passed; since then but two.
6. No.
7. I know of no such instance.

NEWBURYPORT.

POPULATION, 13,716.

1. None.
2. Two. There were seven previous to April, 1887.

3. Four hundred and fifty to five hundred pounds.
5. Decreased ninety per cent.
6. None.
7. No.

NORTHAMPTON.

POPULATION, 12,896.

1. None.
2. None.
4. Seven thousand five hundred pounds.
6. Laws complied with.

WOBURN.

POPULATION, 11,750.

2. Seven.
3. One ton a month.
4. Ten tons a month.
5. None that I have heard.
6. No.
7. None that I can find.

CHICOPEE.

POPULATION, 11,516.

1. None.
2. One; also two pedlers from other towns.
3. Very little
4. Large amount.
5. Good effect.
6. None.
7. Have had no complaint.

PEABODY.

POPULATION, 9,530.

1. Not any.
2. Five.
3. About 600 pounds.
4. About 9,300 pounds.
5. Cannot say.
6. I think they are complied with.
7. I have no knowledge of any.

BROOKLINE.

POPULATION, 9,196.

1. No one has applied for license the present year, or 1887. There were ten licenses granted last year to persons selling from wagons, but since the United States law no one has applied for license.
4. About 5,000 pounds is the estimated quantity sold here per month.
5. Decreased it.
6. I have no knowledge of non-compliance with the laws in this direction.

HYDE PARK.

POPULATION, 8,376.

1. None.
2. Two.
3. Nine hundred pounds.
4. Five thousand pounds.
6. No.
7. No.

Further inquiry was made as to the number of prosecutions made by local inspectors and replies were received from nineteen cities. The total number of prosecutions made by local inspectors was found to be forty-six, all of which were made by the inspector of the city of Boston, and the details of such prosecutions may be found in his letter already quoted.

Legislation in other States and in Foreign Countries.

The manufacture and sale of oleomargarine have been followed in nearly all civilized countries by legislative action of a more or less stringent character, restricting and in some instances prohibiting entirely such manufacture and sale.

The majority of the United States have taken action upon the subject, the States which have enacted prohibitory laws being Maine, Michigan, Minnesota, Wisconsin, Missouri, Pennsylvania, New York, Delaware and Ohio. Vermont prohibits the sale of oleomargarine as butter. Maine forbids the manufacture and sale of spurious butter and cheese.

The law of New Hampshire requires that oleomargarine shall be colored pink. We learn from reliable sources that no oleomargarine of that color has ever been seen in New Hampshire, and yet the report of the Internal Revenue Commissioner states that there are fifteen licensed retail dealers in that State.

Connecticut, Indiana, Iowa, Missouri and California extend the restriction to hotels, boarding-houses and restaurants, where notices must be posted stating that oleomargarine is used there.

Rhode Island, Delaware, Georgia, Maryland and West Virginia provide restrictions as to the marking of packages.

Ohio prohibits such oleomargarine as is not made of beef fat and milk.

In New Jersey it is required that a black band shall be painted around each tub or package, at least three inches wide, and also that the vendor shall inform the purchaser verbally of the character of the article sold, and also present him a card upon which the same information is conveyed, together with the name and address of the dealer.

Decisions have been pronounced in the supreme courts of Missouri, and also of Pennsylvania, in favor of the constitutionality of the prohibitory laws of those States.

In the appendix which follows this report will be found the recent English Margarine Act of Aug. 23, 1887, the German law of July 12, 1887, together with the regulations adopted July 26, 1887, and also the laws of France,

Denmark, Norway and Russia, relating to the same subject.

There are no regulations in Spain or in Italy.

Comments upon Laws.— The English law does not contain any important points which are not already included in the other acts quoted. The name "margarine" which has been adopted in the English act, and which also appears in the German law, is undoubtedly the best name for general adoption, since it is sufficiently explicit to include butter substitutes generally, it is shorter than the word oleomargarine, and is free from the objections to which "butterine" is liable, namely, that of erasing, omitting or covering the final syllable.

The German law provides that the place of business shall be distinctly placarded "Sale of Margarine," as well as the article itself. In the German regulations of July 26, 1887, it is also required that the branding or labelling shall be in black letters upon a white, or light yellow ground, and it is also required that retail packages shall be in the shape of cubes.

The law is quite commonly evaded in Massachusetts by the use of labels or brands of a light green or other light color upon dark brown paper.

With reference to the sale of oleomargarine, and especially as to the requirement that it should stand upon its own merits as an article of food and not appear under a false name, the opinions of authorities are quite unanimous, apart from the question of its healthfulness.

Prof. W. O. Atwater of Wesleyan University, who has given much attention to food questions, says: —

> It is also open to the objection that it is largely sold as genuine butter. The interests of the public, therefore, demand that it should be subjected to competent official inspection and that it should be sold for what it is, and not as genuine butter.

Prof. S. P. Sharples of Boston makes a similar assertion: —

> Its sale as genuine butter is a commercial fraud, and, as such, very properly condemned by the law.

Dr. Jas. Bell, Chief of the Somerset House Laboratory, England: —

When sold as butter, or mixed with it, the sale of the spurious article becomes a manifest fraud.

The Commission appointed at Munich reported March 22, 1887, "that the object of the law was to abolish the adulteration of natural butter with oleomargarine."

It appears that precisely the same difficulties have been encountered in foreign countries, with reference to the sale of oleomargarine, as have been met in the United States. Similar laws regulating its sale have been enacted in different countries, and amendments to such laws have from year to year become necessary, as evasions became common. The following comments of the "Local Government Chronicle" of Dec. 31, 1887, are pertinent to this question: *—

The main business of local authorities under the act will be not so much to supervise the manufacture as to prevent the fraudulent sale of butterine. In this no doubt they will find some difficulty, notwithstanding the very stringent requirements of the statute. However carefully they may have perused the enactments which will now come into force, they may rest assured that the vendors of margarine have devoted more attention than they have done to the matter, that they know the act from end to end, and that some of them have devised more than one way of evading it. We should not be surprised to find that labels have been prepared for the occasion which, while complying with the letter, contravene the spirit of the act, and are calculated to mislead the purchaser almost as effectually as if no attempt had been made to obey the law. But we shall be much mistaken if any such evasions are allowed to succeed. The intentions of the act are clear, and any attempt to defeat them would probably be dealt with very sharply by the magistrates.

The right course for the trade to take will be not to endeavor to evade the act, but to advertise freely the virtues of margarine and its superiority to butter. If they were to adopt this course they would save the local authorities a great deal of trouble, and probably do as well for themselves in the long run as they can hope to do by any evasion of the law.

* "Local Government Chronicle," London, Dec. 31, 1887.

Sir Lyon Playfair in a speech in the British House of Commons used the following language in April, 1881: —

If we could extract butter fats economically from vegetable oils, and give a sound, healthy butter from them at a cheap rate, it would be a matter of indifference to the public whether the butter came from the cow or from the vegetable.

In commenting upon this speech the "Analyst" says: *—

This view of the case may be theoretically correct, but practically it matters a great deal to the consumer whether he pays for butter substitutes at a genuine butter price. Oleomargarine is beyond question a very wholesome and useful article of diet when it is prepared from clean and sweet fats, and there can be no possible objection raised to its sale *as oleomargarine*. But, as a matter of fact, it is sold only as an admixture with genuine butter, the admixture — whether of the highest or lowest grade — being invariably sold as butter.† *This is the only fraudulent part of the business and the only genuine cause of complaint which the British dairy farmer has with regard to the matter.* The fraudulent sale of adulterated dairy products should be adequately prevented by legal enactment, and then the action of consumers would settle the trade on a firm and definite basis.

Dr. Charles Girard, Director of the Paris Municipal Laboratory, says in his first, and repeats the statement in his second, report: —

The margarine prepared in this manner, and sold under its true name, renders important service, and enables the families of the working classes to furnish themselves at a low price with a fat of a taste and quality often superior to the butter of an average quality which is found abundantly in our markets.

Unfortunately, speculation, or rather fraud, has here discovered a source of great profit, while a few establishments make their margarine honestly. The fats which are actually employed are of all sorts. Instead of using that which surrounds the kidneys and the intestines of beef-cattle, the maufacturers of margarine utilize tallow of every kind of production; only the minimum of cost influences them in their choice of the raw materials.

The substance which they remove from this mixture of fats is churned, with oil and milk in a proportion intended to secure the

* The "Analyst," London, 1881, vol. 6, p. 167.

† This statement was made before the enactment of the British Margarine Act.

consistence of butter. The coloring-matter added is saffron, annotto, or turmeric.

Finally, the product obtained — which results either from a good or a bad process of manufacture — is, like pure butter, divided into one pound rolls, wrapped in a thin cloth, to be finally offered for consumption under different names (unfortunately, very often under the simple name of butter). Often also, the makers do not take the trouble to divide it into rolls but sell it in bulk to traders, who mix it in varying proportions with pure butter.*

Summary of Work Done in the Inspection of Butter and Oleomargarine.

The following summary includes the statistics of work done under the supervision of the State Board of Health with reference to oleomargarine up to the date of this report (March 23, 1888). Each sample included in this summary was submitted to thorough chemical analysis by the analysts of the Board: —

Total number of samples collected,	604
number of persons or firms from whom samples were obtained,	451
number of samples marked "oleomargarine" or purchased as "oleomargarine," †	21
number of fraudulent sales,	122
number of samples collected previous to Oct. 1, 1886,	175
number of fraudulent sales previous to Oct. 1, 1886,	59
percentage of fraudulent sales " " "	33.7
number of samples collected from Oct. 1, 1886, to Feb. 1, 1888,	173
number of fraudulent sales from Oct. 1, 1886, to Feb. 1, 1888,	44
percentage of fraudulent sales from Oct. 1, 1886, to Feb. 1, 1888,	25.4

* Documents sur les falsifications des matières alimentaires: First Report, Paris, 1882, p. 292; Second Report, Paris, 1885, p. 376.

† In explanation of this item it should be said that a small number of the samples purchased by inspectors between Oct. 1, 1886, and Feb. 1, 1888, were found to be stamped "oleomargarine" after the packages were examined. Thirteen of those which were collected for this special inquiry after Feb. 1, 1888, were found to be so stamped. In a very few instances oleomargarine was called for. The exact number of such samples to which a "fraudulent sale" could be attributed could only be determined by the circumstances in each particular case. In either event such cases were comparatively few, and would not increase the percentage of fraudulent sales since Feb. 1, 1888, to more than 8 or 9 per cent.

Number of samples collected and examined since Feb. 1, 1888 (special inquiry), ...	256
number of fraudulent sales since Feb. 1, 1888, . . .	19
percentage of fraudulent sales since Feb. 1, 1888, . .	7.6
number of prosecutions,*	57

To interpret the foregoing summary it will be convenient to divide the work of the Board relative to oleomargarine into three periods.

First. The period previous to Oct. 1, 1886.

Second. The period from Oct. 1, 1886, to Feb. 1, 1888, which coincides nearly with the time since the national law became operative.

Third. The brief period since Feb. 1, 1888, in which special work has been undertaken in aid of the present inquiry ordered by the Legislature.

It will be noticed that the percentage of fraudulent samples obtained in the first period named was 33.7; in the second period, 25.4; and in the third period, 7.6.

These figures may undoubtedly be taken as conclusive evidence that the laws are much more effective in their operation at the present time than they were previous to October, 1886, and also that there has been a very decided further improvement since the latter date.

* This item does not include separate complaints, but has reference to the number of individuals or firms against whom complaints have been made. In some instances several complaints were made against a single party for violation of different provisions of the law.

THE HEALTHFULNESS OF OLEOMARGARINE AS AN ARTICLE OF FOOD.

By ELLIOTT G. BRACKETT, M.D.

It is the writer's object to consider the subject of oleomargarine as far as possible from a stand-point of healthfulness alone, and to regard it individually as an article of food. However, both in its intended use and in its composition, it is so intimately connected with butter that it is scarcely possible to entirely disregard this relation; but, except as may be necessary for such comparison, it has been given a strictly individual position. No account has been taken of its value as a food for invalids, but it has been considered as an article of food for use by those who ordinarily do not make restrictions in their diet.

Already so much has been written and so many opinions expressed, by experts and others, that, especially as to the chemical view of oleomargarine, there is no lack of information, and from men best qualified to give opinions; but, as it was the object to present a purely unbiased opinion on this sanitary question of oleomargarine, it was thought best that such should be given first from evidence obtained by a practical acquaintance with the processes of manufacture as carried on to-day; and, therefore, all places where such manufacture was conducted in New England were visited, and its manufacture seen, as well as that of the oleo oil and lard. In addition to this information and that obtained from the reports mentioned, are the results of experiments personally conducted, mainly on a physiological basis, with the object of determining the digestibility of the products.

Application of the Terms Oleomargarine and Butterine.

These terms, which have been at times intended to designate different and distinct divisions of artificial butter, have been so freely and interchangeably used, that at present there is practically no difference made, and they are used synonymously. Strictly speaking, oleomargarine applies to an artificial butter, in the manufacture of which no natural butter has been added other than that from the milk used in the churning; and butterine is that which has natural butter as one of its ingredients, and is therefore a mixture of oleomargarine and butter. The national law has made the term oleomargarine to apply to all forms of artificial butter and butter substitutes, and requires them to be stamped as such. By this law oleomargarine includes "all manufactured substances heretofore known as oleomargarine, oleo oil, oleomargarine oil, butterine, lardine, suine and neutral, and all mixtures and compounds of oleomargarine, oleo, oleomargarine oil, butterine, lardine, suine and neutral; all lard extracts and tallow extracts, all mixtures and compounds of tallow, beef fat, suet, lard, lard oil, vegetable oils," etc., so that each of these substances, either alone or in mixtures, is classed under the one head of oleomargarine. Although such an array of articles of this class is gathered legally under this head, practically its significance is far less, and is applied only to the two mixtures above alluded to, intended for butter substitutes, and known as butterine and oleomargarine.

The origin of oleomargarine, resulting as it did directly from scientific investigation, should not be passed over without mention. A complete description of the process may be found in almost every article on oleomargarine, and I shall therefore allude to it only briefly and so far as may be necessary for use in comparison with the present methods of manufacture, which are but modifications and improvements on this original process.

Original Process.

In 1866–67 M. Mége Mouries, following the request of the French government, undertook to obtain a compound which

should take the place of butter. His object was to obtain the same product by substituting an artificial for a natural process. By experiments he found that by depriving cows of nourishment, so that they were losing weight, their milk still contained butter; and, inferring the source of this to be the natural fat, which, by metamorphosis, was secreted as butter, he accordingly endeavored to imitate this process as closely as possible.

He considered that in the transformation into butter fat, the presence of ferments played an important part, and these were obtained by extraction from the animals. All fats which were to be used in the manufacture of the oleomargarine were first soaked in water containing sea-salt and one per cent. of sulphite of soda. This was to neutralize a ferment which he supposed to cause the disagreeable taste of fat. The fat was then thoroughly crushed and hashed, and subjected to the action of artificial gastric juice at a temperature of 103° F. (40° C.), until digestion had so far advanced that all lumps had disappeared, when the whole mass was allowed to settle, the clear fat cooled and subjected to high pressure to separate the stearine, the fluid portion coming from the press being the oleo oil, the part used in the manufacture of oleomargarine. As thus extracted, he obtained a product of a slightly yellow color, with a taste resembling neither tallow nor fat; and under the name margarine, this was used extensively for kitchen purposes.

He supposed the fat, before being secreted in the milk, to undergo change by the influence of a ferment, and in his artificial process he endeavored to change this into butter fat by the same agency. He therefore churned the melted fat with finely-chopped, fresh cows' udders, and, to give the ordinary flavor of butter, milk or cream was added. The product thus obtained resembled butter in appearance and taste. He thus realized the object of his theory in obtaining the product by an artificial process, but from the same source; deriving the fat from the animal, extracting the more solid portion, that it might be fluid at a temperature below that of the body, using natural ferments for metamorphosis into butter fat, and imparting the flavor by the use of milk. He gave to this product the name oleomargarine, as the term

margarine had long been used to designate a substance which was found by Heintz to be a mixture of stearine and palmitine, but which does not exist in nature, although it has been obtained by synthesis.* How much this process has been changed in order to supply a large demand for the article, and to satisfy the requirements of more rational chemistry, will be seen. The name has been held to apply, in a way, to the different butter substitutes.

On this process he took out a patent in England in 1869, and in America in 1872. Since that time a very large number of patents have been issued, on improvements, and methods of preparing fats, and making of butter substitutes. The rendering of the fat at a low temperature, and the conversion of the oil into butter by churning with milk, were original with him, and form the most important feature of the process. (Proceedings American Chemical Society, vol. I., p. 155.) One patent, which resulted in the most important improvement, was the instantaneous chilling of the oleomargarine, when drawn from the churn, by contact with ice or ice-water, which gives it a "grain" more nearly resembling butter. The patent for this improvement was taken out by H. A. Mott.

By this time several changes had been made in the original process, mainly in the direction of making it more simple, and among these was the omission of the use of ferments; but scarcely any other essential change has been made, though details have been considerably modified, and there is also difference in the methods of different manufacturers at present. These differences, as far as could be judged, are mainly in the temperature used throughout the manufacture, and in some cases this varies considerably. In addition there are special peculiarities which would necessarily result from many individuals making the same product, and which are more matters of skill and judgment, the result of long experience, and which the manufacturers claim for themselves, but which are neither tangible to an investigator, or possibly explicable even by the workmen; but such is the fact, as was frequently mentioned, that the maker

* U. S. Dispensatory, 1883, p. 980.

attained a certain skill by long practice, which insured good results, without which the same method, though strictly adhered to, would give far inferior success.

In only very few of the New England manufactories are the oleo oil and the oleomargarine made by the same party, and in the same place, as oleo oil is a regular article of the market, and its manufacture a separate industry.

There are two kinds of fats used in the production of oleo oil, and they yield two grades of oil, — the fat from the freshly killed animal, which gives the better, and the suet fat, which yields a somewhat inferior grade. The oils in the market differ in quality, this difference seeming to be the result of skill and judgment in the extraction, rather than of the material used, as the latter is more uniform. Each manufacturer makes the two grades, which are called by distinguishing names, and in the quotations are known by such.

During the preparation of this report, not only was the process of manufacture of oleomargarine investigated, but also that of oleo oil and lard, and all following descriptions of processes are from those seen during this investigation.

Manufacture of Oleo Oil.

For the first grade, the caul fat, or, as it is sometimes called, "slaughter or long fat," is used. This is trimmed in the room where the slaughtering is done, and sent through holes in the floor to a room below, where it is received in tanks filled with water which has had the chill removed (about 80° F., 27° C.). Here it is left for a while and then transferred to tanks containing ice water. This gradual cooling seems to be a necessity, since, if plunged at once into ice water, the outside is suddenly chilled, and the animal heat remaining in the centre of the mass sours the whole. This fat, when cool, is passed through hashers, and run into steam-jacket kettles and thoroughly melted, being stirred continually. The temperature in this process is about 140° F. (60° C.), or lower, although it may be as high as 165° (74° C.). The time necessary to completely melt the mass is about three hours. The scrap is now allowed to settle, and the clear oil is drawn off by a pipe which drains from the top only. This oil is again allowed to stand from six to

twelve hours, as may be necessary, that the water and remaining pieces of fibre may settle, and this sediment is withdrawn through pipes in the bottom.

The process of extracting and clarifying is now completed, and it remains only to separate the stearine, which is the part of the fat not used in the oleomargarine. Up to this time the temperature has not been allowed to fall, but the fat has been kept in a melted state. The cooling or "seeding" takes about three days, and for this it is placed in large receivers and kept at a temperature of about 80° F. (27° C.), until the stearine has gathered. This begins by the formation of very small particles, which afterwards collect in the centre of the mass, and grow like a sponge. When ready for pressing it is a semi-solid mass, somewhat coarsely granular in appearance. Small quantities are packed in cloths of heavy ducking and laid between plates, about twelve in each section, and subjected to a very heavy pressure. The press room is kept warm, but at a temperature below that of the seeding room. The oil thus expressed constitutes oleo oil, and is a mixture of oleine and palmitine, while that left in the cloths is in white, hard cakes, one-fourth to one-half inch in thickness, and consists of pure, or nearly pure, stearine. The oleo oil, as it comes from the press, is a clear, amber-colored fluid, free from odor or fatty taste. This is packed in tierces, and, when opened at ordinary temperature, is a light yellow solid.

For the other grade of oil the suet fat is used. This is carefully sorted and trimmed, no part being used unless it is perfectly sweet. This then passes through the same process as is described above.

Variations in this process are found with the manufacturers, with reference to detail, but in its essential steps it is the same.

The advantage of having the place of manufacture near the slaughtering house is an evident one, allowing no opportunity for the fats to become sour by waiting for transportation, although with care this can be reduced to a minimum.

The temperature used by different makers, in rendering the fat, is subject to some variations; but these apply rather to the extremes which are considered safe, than to the actual

heat used. Some do not allow a heat greater than 140° F. (60° C.), and practically use one much less; by others 160° F. (71° C.) is considered safe. However, the aim is to avoid high temperatures. In this particular there is a departure from the original method of Mége Mouries, who specified that the temperature should not be carried above 125° F. (52° C.), claiming that in so doing one incurred the risk of the disagreeable greasy taste in the product, which it is very essential to avoid. The temperature of the seeding room is not one of uniformity, but ranges between 80° and 95° F. (27° and 35° C.).

Besides the oleo oil, there enter into the composition of oleomargarine, milk, butter, lard, cotton-seed and sesame oil, occasionally peanut oil, and coloring-matter. The basis of the mixture is oleo oil. To give this the flavor of butter, it is churned with milk, or milk and butter. Experience has shown that better results are obtained when the milk is slightly sour, and it is therefore kept until it has "just turned." In all places visited, fresh milk was seen standing in a warm room, for use either in that afternoon's or the next day's churning. The butter is added for the same purpose, and, that it may impart a good flavor, must be of good quality in itself.

Oleo oil is, at ordinary temperature, brittle, and, when cut, crumbles like cheese. To give it a consistency resembling butter, some oil or fat which has a much greater consistency is added, and for this purpose lard and the vegetable oils mentioned are employed. The effect of all these is in the same direction, and they are used in different proportions by different makers. Sometimes lard is used without the addition of any of the vegetable oils. In cold weather more is added, to counteract the greater tendency of the oleo oil to crumble at lower temperatures.

For coloring-matter, annotto is quite universally used.

In the manufacture of oleomargarine, the fatty substances are melted, and the churning done at a temperature which keeps the mass in a melted state. The ingredients are added at certain stages of the process, according to the method of the maker, but a more or less definite plan is adhered to by all.

In general, it may be said that first the milk is churned until the butter begins to come, when the oleo oil is added and churned; later, the lard and vegetable oils, and finally the coloring-matter. The butter is added in one of two ways — either in the churn, in which case it is melted, or it is mixed in with the oleomargarine in the solid state, in the process of working. The churning occupies about two hours, and is conducted at a temperature above the melting point of the fats used, or about 80° F. (27° C.). Toward the completion the temperature is raised somewhat, and when the contents are ready to be drawn it has the appearance of a somewhat yellow, creamy fluid, being at this time at about 90° F. (32° C.). It is at this part of the process that one of the greatest improvements has been accomplished, namely, that of sudden cooling by contact with ice or ice water; and, by bringing every particle of the fluid into contact with the ice, it is broken up into a light, granular-appearing solid, and is given the so-called "grain." This is accomplished either by drawing the contents of the churn into a tank containing pounded ice, stirring continually, or by bringing the stream from the churn in contact with a stream of ice water. This chilled mass is then placed in large trays, and the water allowed to drain, when the salt is added, and the mass left to stand from twelve to twenty-four hours, until the salt has been dissolved and thoroughly mixed. From this stage it is handled in much the same way as butter. It is thoroughly worked by passing through wooden-cogged rollers, and is then ready for packing.

Although the process of manufacture of the oleomargarine differs in detail with every manufacturer, these differences are mainly technicalities. The principle, however, is the same, and involves the two points of Mége Mouries, and the one of Mott; viz., the rendering of all fats which enter into the composition at a low temperature, the flavoring of these by churning with milk, the addition of butter, the addition of a sufficient quantity of lard or vegetable oil to give the product a proper consistency, and the sudden cooling of the whole, in order to give it a "grain." In regard to the differences above alluded to, they are chiefly in matters of temperature at which the steps of the process are conducted, in the addition

of the ingredients to the churn, and the length of time these are churned, etc. But as the object of the author is to give information in regard to oleomargarine in general, this mention will be considered sufficient.

Sanitary Aspects of the Case.

Having considered the process of manufacture, we can now better judge of the healthfulness of the product, by attention to the substances used, the influence of the method of manufacture, and the product itself, each in its sanitary aspect.

Of fundamental importance is the quality of all substances that enter into the composition of oleomargarine, for, unless they are pure and wholesome, the quality of the mixture must necessarily suffer. All constituents used in the manufacture of oleomargarine are commercial articles, and, with the exception of the oleo oil, are of common household use, finding entrance into our food in many other ways, either alone or in combination with other things. The oleo oil is more restricted to the use of making artificial butter, yet not wholly so, as it finds considerable favor with those accustomed to its use for kitchen purposes.

With reference to the healthfulness of the oleo oil, its manufacture as has been described may be considered. It is made from beef fat taken either at the time of slaughtering, or from the suet fat taken at the time the beef is cut for ordinary use. In the first instance, great care is taken, not only to obtain the fats in a perfectly fresh condition, but they are allowed scarcely an opportunity for change. The suet fat is taken at the time when the beef is sold for table use, and is then carefully sorted and trimmed, that no part which has been bruised or tainted may be used. The process, simply stated, consists merely in rendering these fats at a low temperature, so low that it is rather a process of melting, and this is the great surety to the strict use of good fats only. It is a necessity that pure, sweet material shall be used, for otherwise the product is tainted, even by a very small portion. On the other hand, a higher temperature cannot be used without the risk of imparting to the oil the disagreeable greasy flavor, which destroys its value for this use.

Observation in all places bore out in practical illustration the above. In no case was the material used other than sweet, and also all parts of the process were conducted with cleanliness. All utensils were required to be washed with hot water after each time of using, for, if ever so little were left with the opportunity of becoming sour, the following lot would be spoiled, so readily do the fats take up odors.

It is claimed, quite universally, that the lard which is used for oleomargarine is of a better quality than much of the ordinary material in the market, which is, nevertheless, pure lard; and that, in the making of lard for this purpose, only the leaf is used. The difficulty in proving this fact is evident, since the manufacturers of oleomargarine, except in a very few instances, purchase the articles in the market, and these, therefore, come from different sections of the country, so that a satisfactory inspection of parts utilized in the manufacture of the lard used in oleomargarine would be scarcely possible. Not every manufacturer of lard makes that which is destined for use in oleomargarine; and the only one in this vicinity, whose brand was used in the factories visited, denied permission to see the process and material. In but one of the places was the lard rendered by the manufacturer of the oleomargarine. Here the material was seen, and the leaf alone was being used.

Four samples collected at the oleomargarine factories were submitted for examination. Two proved to be pure lard; the others contained a considerable amount of tallow. That which was rendered by the maker of the oleomargarine, and one of the commercial specimens, were pure lard.

Of the vegetable oils, cotton-seed and sesame oils are used by far the most. I am told by some of the workmen that peanut oil is still used to some extent in Holland, but here in New England but very rarely.

These two oils it is scarcely necessary to discuss from a sanitary stand-point. The common use of cotton-seed oil has already given it a recognized place as an article of food, and it is familiar to all through its common use. It has no medical properties other than those of a bland neutral oil. Like all articles, however, there may be good and poor preparations, and an inferior grade may result from lack of

proper care of the seed before the oil is expressed, allowing it to become musty; but oil made from such, if used in oleomargarine, would injure the taste. Care was taken to see and taste this oil in the different places, and it was found clear and sweet in each case.

Sesame or benne oil is perhaps less familiar in this section of the country. It is a fixed oil, obtained by expression from the seeds of the *Sesamum indicum*, a native of the East Indies, but now cultivated extensively in the West Indies and Southern United States. The seeds are used as food by the negroes, who parch them, make them into soups, puddings, etc. It was known to the ancients [Persians and Egyptians], and is used by modern Arabs for food. In taste and appearance it resembles cotton-seed oil very closely. It consists of about 76 per cent. of oleine, and has the quality of keeping a long time without becoming rancid.

Coloring-Matter.

For coloring-matter, annotto is quite universally used. This coloring-matter is in itself quite harmless, and would become unwholesome only by injurious methods of preparation. The annotto seed is the fruit of the *Bixa orellana*, growing in Guiana, and the color is obtained from the reddish pulp surrounding the seed, and can be extracted by ether, alcohol and the oils. For use in oleomargarine it is obtained by boiling in salad oil, which furnishes a reddish-brown fluid, with a not unpleasant nut-like taste. The color is intense, and only a small amount is required for a large quantity of butterine.

Influence of the Process.

The process as a whole is the same mechanical one that is used in the making of butter, with the exception that with oleomargarine the process is conducted at a temperature above, and with butter below its melting point. The cohesion into a solid greasy mass is obviated, in the instance of the former, by the sudden cooling, which breaks it up into a state of fine subdivision, and in this way it differs from an ordinary melted mass.

The process of manufacture was in every case conducted

with cleanliness, and all utensils which were not in use at the time were seen to be clean and sweet.

Thus we have articles used in the composition of oleomargarine which are in themselves wholesome, and are used for ordinary household purposes. These are mixed by a mechanical process, and at a temperature which does not exceed that of the body, and this process exerts no injurious influence on the product.

The other points which present themselves in this sanitary inquiry of oleomargarine, are its relative tendency to deterioration, its danger from the accidental admission of parasites, its nutritive value, and its digestibility.

The Question of Keeping.

It is a matter of common observation, that, in this regard, oleomargarine is superior to butter, becoming rancid less readily; and, considering its composition, this would be expected, since it is a mixture of pure fats, and contains but a very small amount of caseine and butyric acid.

Parasites.

On this agitated question much has been written, not all of it with justice to the subject, there being a tendency, with some, at least, to over-estimate the liability of harm. The danger pertains to two questions, — the liability of the parasites to enter into the product, and the danger from the ingestion of the same after having been subjected to the processes used in the making of oleomargarine and its constituents.

We know that these organisms do at times exist in the animals from which certain of the ingredients are obtained; but what the chances are for these to be transferred into the oleomargarine is a matter for consideration.

The danger from these organisms comes from the use of lard or oleo oil which has been made from hogs or beeves affected with trichinæ, cysticerci, or tuberculosis. The other parasites or germs are either so infrequently met with, that they may be disregarded in a consideration which involves only the practical side of the question.

It should be remembered that these substances are made

from the same animals that are slaughtered for our ordinary table use, and official inspection will prevent, in a great measure, the use of unwholesome material.

It is only by the flesh of the hog that man incurs any practical danger of trichinæ. As is well known, the natural seat of these organisms is in the muscular tissues. That occasionally some are found in fat may be true enough, for, considering their mode of entrance into the muscle, it is not at all unreasonable to suppose that some should fail to reach the muscle, or should be in transition. But the muscular tissue is the part in which we look for and expect to find the trichinæ, when they exist, and the fat can be regarded only as a remote or possible source of this infection.

In case any do find their way into the oleomargarine, the processes to which they are subjected, although not surely fatal to them, yet leave them only a chance of survival. The temperature at which the lard is rendered varies considerably with different makers, but in most cases is sufficient to give protection against infection. In order to be secure against trichinous infection, it is necessary that the whole mass should be subjected to a temperature of 65° or 70° C. (150° or 160° F.), and a lower temperature is considered by some authorities sufficient to render trichinæ inactive. Ordinarily, in the manufacture of lard, the temperature would be fatal to them, but in the manufacture of oleomargarine and its constituents, too high temperatures are avoided, and with this there will be the chance that protection may not be secure. But the oleomargarine still has another process which is injurious to the trichina, namely, the salting. If thoroughly done and for a long time, a salted article is proof against trichinæ. Oleomargarine contains as a rule about five per cent. of salt, and, although we can scarcely conclude that this amount would protect a highly infected article, yet it can be regarded to a certain extent as protective.

The cysticercus is the immature tape-worm, developed from the ovum of the tænia, and when ingested becomes in the intestine a fully developed tænia. The eggs of the tænia, finding their way into the alimentary canal, are transported to different parts of the body, where they develop

into their immature state, or larvæ, called cysticerci, their complete development into tape-worms taking place only when the flesh containing them is eaten, and they find their way into the alimentary canal. This circle is ordinarily maintained by transference among animals.

There are but two kinds of tænia which are commonly found in man,—the tænia solium, and the tænia saginata. The former is acquired by eating the flesh of hog containing its corresponding cysticercus, and which, when present in large numbers, produce in pork the condition characterized as measles,—the latter, a parasite of the ruminants, is acquired by man by eating beef so infected.

Since the flesh of these animals forms so large a part of man's food, the tænia is the form most commonly met with in man; the ova necessarily having much less opportunity of entrance, the cysticercus is less frequently seen. But it is the ingestion of the larvæ, with which a consideration of oleomargarine has to deal. With regard to the chances of these entering into the product, the same is true as of trichinæ. The parts used in the manufacture of oleo oil are not the natural home of these larvæ, but the same danger exists of stray ones. The temperature used in the extraction of the oleo oil gives more prote tion, although with the original process of Mége Mouries a temperature of 124° F. (51° C.) was not exceeded; but the present manufacturers use a much greater heat, and for a considerable time. The danger which results is far less than with trichinæ, as the effects of the tænia on the human system are much less injurious.

Tuberculosis.

This topic is intended to represent not only tuberculosis, but the various epidemic diseases which prevail at times, and which are now quite generally accepted to be caused and spread by germs. The relation that many of these bear to tuberculosis, and how many are attended with tubercular deposits, the author would not venture to state from information obtainable at present. These epidemics have been known by so many different names, which have been used with such a general significance, that to separate them into

distinct types, by any pathological classification, and as such to consider them, would not add clearness to the discussion, or accuracy to the observation. Their influence, so far as the effect of the consumption of the fat of their victims is concerned, is in the same direction, so that to consider them collectively is proper, because they all have pronounced and more or less characteristic symptoms, and manifest themselves in constitutional disturbance, that betrays the existence of the disease in the living animal to even an unskilled observer. The ingestion of the flesh of the infected animals is liable to be followed by sickness, and in the epidemics which have prevailed, the effect of eating the flesh was an increase of severe diarrhœal disorders.

Against danger from this source, conveyed through the fats used in oleomargarine, we must look to the general inspection of the condition of animals brought to slaughter. The evident presence of diseases of this class is favorable to the enforcing of such regulation; but oleomargarine has but a small share of the interest in this general question, and should be fully protected by those restrictions on the killing of any animal intended for use as food.

Nutritive Value.

A very important consideration in this question of the healthfulness of oleomargarine is that of its nutritive composition, its value in supplying the necessary principles of a food; and in this regard Prof. Atwater has made a valuable contribution. In Bradstreet's (June 19, 1886), he says: "The value of butter, as well as of any other food material for nourishment, depends upon the amount of its nutritive ingredients, their digestibility, and their uses in the nutrition of the body."

He has published in the "Century," tables showing the comparative value of different foods, viewed from various standpoints. In many of these, comparison with butter is made.

In regard to the nutritive value, the amount of solids in butter is between one and two per cent. more than in oleomargarine, this being made up mostly by proteids, and the remaining fraction of a per cent. by fat (calculated from

measurements of the tables). Thus, in their nutritive composition, butter and oleomargarine are practically the same.

The other tables have reference to the relative cost, calculated from the amount of nutrition obtained for a definite sum, and, although of no less interest, yet perhaps have less bearing on our present subject; but, from this monetary view, they are very important, since it is the workingman who is in the greatest degree affected by oleomargarine. These tables represent the amount of nutritive elements obtained for a definite sum, in the different kinds of foods, and the amount of potential energy furnished by the various foods, for the same sum. Fat is the only nutritive ingredient furnished by either butter or oleomargarine to a practical amount. The amount furnished by oleomargarine is twice that by butter. The potential energy, expressed in calorics, in oleomargarine is 6164, in butter 3182. Therefore, as a monetary consideration, oleomargarine and butter supply almost the same amount of food material, and, for the same money, oleomargarine yields nearly twice the amount of food principles as does butter.

In this question of the healthfulness of oleomargarine, the consideration of its digestibility is a most important factor. So far, but little more than individual opinion and certain isolated facts are known concerning the digestibility of different fats. It is scarcely possible to consider this point with reference to oleomargarine without drawing comparisons with butter, with which it is always associated, and concerning which there is at least a practical knowledge of its value as food. To class it among the fats alone would give no idea of its value as a healthful food, as they differ to a great extent, and digestion and assimilation vary so much both with the kind of food and with the individual. In the few experiments which have been made to compare the absorption of oleomargarine the results have been slightly in favor of butter. Those of Meyer gave preference to butter by 1.6 per cent., but they were conducted for so short a time that the results are not of great value. However, all others give similar results. In Bradstreet's, Prof. Atwater mentions experiments made by himself and Rubner,

which resulted in no calculable difference, and in no case was there more than is allowable for error.

The results obtained by artificial digestion are of no indication of the amount which may be absorbed, nor of the actual results of natural digestion, yet they are of value if used comparatively; since, if all the substances used are subjected to the same conditions, the degree to which they resist or yield to the action of this artificial digestion will be a means of estimating the results of natural digestion of the same substances. In this way can we judge of the result of the action of pancreatic fluids on the fat, but the absorption must depend more or less on individual differences, and is a process scarcely practicable to imitate.

Speaking broadly, the object of the process of digestion is to change the food into such a form that it may be absorbed and pass into the system. Different nutritive principles require different processes for this preparation, such as the starches, proteids and fats. This preparation of the fats consists in breaking them up into a state of fine subdivision and suspending them in a medium to form an emulsion. In this finely divided state fat is absorbed by the intestines, and may be found in the vessels to have been absorbed without further change than the division, and by the microscope is seen to be in minute globules of about $2\frac{1}{2}$ *m.m.m.* and under; therefore, the essential feature in the process of the digestion of fats is the formation of a fine emulsion.

This emulsion is produced by a ferment contained in the pancreatic juice, and, as this is easily extracted, this same process of emulsifying may be produced in an artificial manner. The pancreatic juice, acting on the fats, splits them up into their respective fat acids and glycerine, and this takes place much more readily in an alkaline medium. The free fat acid combines with the alkalies which are present, and forms soluble soaps, which aid in the emulsion of neutral fats; at least, the presence of a soluble soap favors the emulsion of neutral fats. It is stated by Foster, and is repeated by Dr. Clark in the second report of the New York Dairy Commissioner, that a fat containing a free fatty acid forms an emulsion more readily than a neutral fat. In the intestines we have this condition, which is most

favorable for the emulsion of different fats, for the pancreatic juice supplies free fatty acids, while both pancreatic juice and bile furnish the alkaline medium. The presence of bile favors this process, if nothing more, and presumably also the subsequent absorption of the emulsion.

In the experiments of artificial digestion, a known quantity of the oleomargarine or butter was taken, and kept between 100° and 104° F. (38° and 40° C.), and not allowed to vary beyond this limit. In all cases the same amount was used, so that the results of all might have a uniform basis, and difference in the results should be due only to change in conditions. In these experiments two tests were used for determining the emulsion, and two observations of its thoroughness were made on many samples. The tests were macroscopic and microscopic. When a fat or oil is completely emulsified, a change occurs in its gross appearance, which is nearly as definite as that which is determined only by the microscope, which was used to confirm this change in nearly every instance. An emulsion is simply a state of fine subdivision, the fat being broken up into minute definite globules, the size varying considerably with the kind of fat and the completeness of the emulsion. When the emulsion is complete, not only can it be seen that the mass is composed of minute globules, but it has become much thicker and lighter in appearance. A butter, for instance, which at 140° F. (40° C.) is fluid and is easily poured, becomes nearly semi-solid, and is poured only slowly. The microscope shows this subdivision, at this stage, as quite complete, as may be seen by reference to Fig. 7. When this state had been produced, the emulsion was called complete. On the other hand, there is a stage before this is reached, when the emulsion will remain permanent, the two portions, the oil and the emulsifying agent, not separating on standing and cooling. With an insufficient quantity of emulsifying agent, although a fine subdivision may be readily obtained, the separation quickly takes place, the globules not remaining distinct, or a part remains in emulsion, the separated portion collecting as a clear oil on the surface. This permanency is perhaps the most valuable ready test of the thoroughness of an emulsion. But, as

these experiments have shown, the emulsion may be permanent before the subdivision is as minute, as may be produced by continuing for a longer time the same conditions, or by an additional quantity of emulsifying agent. Therefore, these two observations of the permanency and completeness were made, and both conditions tested by gross and microscopic change.

In the following tables, I., II., III. and IV., the usual quantity of oleomargarine or butter was taken, and to this was added a solution of extract. pancreatis every fifteen minutes, until the desired emulsion was obtained, the object being to determine the amount necessary to bring about this change. The total amount necessary with the same samples is seen to vary somewhat in the different groups, due to varying conditions in the experiment, as, for instance, the amount of agitation, which was purposely not the same with each series; also, the amount of solution added at first, which seems to influence the total amount necessary. In each of these groups a butter was used, that the results of the other samples could be compared, in which way only it is intended the results should be considered.

TABLE I.

Solution used: Extractum Pancreatis, 1 per cent. Showing amount necessary for complete emulsion; observations of permanent emulsion not taken. Tests were made by gross appearance, and a uniform subdivision shown by examination and hand lens. Solution added in amounts of 0.5 c c.

SAMPLE.	Amount used.	Amount of emulsifying agent used.
A (oleomargarine), ...	10 c.c.	2.00 c.c.
9205 (oleomargarine), ...	10 c.c.	2.00 c.c.
9209 (oleomargarine), ...	10 c.c.	2.00 c.c.
L (oleomargarine), ...	10 c.c.	3.00 c.c.
E (butter), ...	10 c.c.	1.50 c.c.

TABLE II.

Solution used: Extractum Pancreatis, 1 per cent. Showing necessary amount to form a permanent emulsion; process not carried to complete emulsion.

SAMPLE.	Amount used.	Amount of emulsifying agent used.
A (oleomargarine), ...	10 c.c.	1.50 c.c.
H (oleomargarine), ...	10 c.c.	1.75 c.c.
B (oleomargarine), ...	10 c.c.	1.30 c.c.
9207 (oleomargarine), ...	10 c.c.	1.50 c.c.
9205 (oleomargarine), ...	10 c.c.	1.75 c.c.
E (butter), ...	10 c.c.	1.25 c.c.

TABLE III.

Solution used: Extractum Pancreatis, 1 per cent. Showing amount necessary to form complete emulsion, as determined by gross appearance, and also microscopic examination.

SAMPLE.	Amount used.	Amount of emulsifying agent used	
A (oleomargarine), . .	10 c.c.	2.50 c.c.	
L (oleomargarine), . .	10 c.c.	2.75 c.c.	Emulsion not equaling the others either in fineness or uniformity.
O (cheap butter), . .	10 c.c.	2.75 c.c.	
P (good butter), . .	10 c.c.	1.50 c.c.	
R (good butter), . .	10 c.c.	1.50 c.c.	

TABLE IV.

Solution used: Extractum Pancreatis, one-half per cent.; added at long intervals.

SAMPLE.	Amount used.	Amount of emulsifying agent used.
U (oleomargarine), ...	10 c.c.	3.45 c.c.
T (oleomargarine), ...	10 c.c.	3.15 c.c.
S (oleomargarine), ...	10 c.c.	2.95 c.c.
H (oleomargarine), ...	10 c.c.	3.20 c.c.
W (oleomargarine), ...	10 c.c.	2.95 c.c.
L (oleomargarine), ...	10 c.c.	3.45 c.c.
X (oleomargarine), ...	10 c.c.	3.20 c.c.
9205 (oleomargarine), ...	10 c.c.	3.20 c.c.
O (cheap butter), ...	10 c.c.	3.70 c.c.
E (good butter), ...	10 c.c.	2.45 c.c.
P (good butter), ...	10 c.c.	2.45 c.c.
R (good butter), ...	10 c.c.	2.45 c.c.

As stated above, the tables show some differences, as the conditions were not the same in all; but the object was in all cases to so present the results, that, with the same conditions, butter and oleomargarine might be compared. A good quality of butter, in all cases, forms a permanent emulsion more readily and easily than oleomargarine, and this emulsion which is formed is at first a little finer and more uniform. There is scarcely any difference in the manner in which the substance is broken up immediately after adding the emulsifying agent; but the oleomargarine separates more quickly, and the formation of the permanent emulsion takes a little more time and agent. In one other particular there is a difference at this stage. With both, before the emulsion is permanent, when allowed to stand, the fat separates and arranges itself in layers, the under consisting of the part which stays in emulsion, the upper, that which separates. In case of butter, the separated portion resembles, in appearance, the melted butter before the emulsifying agent was added; while, with oleomargarine, this differs from the melted oleomargarine, being lighter and thinner, suggesting that it is some one of the ingredients of the oleomargarine which resists more strongly than the others. Also, after the permanent emulsion is formed, there is more resistance by the oleomargarine to the finer subdivision, requiring more time and agent than the butter, which seems to pass into this state more readily and steadily. This is shown in Table III., in which, especially, the process was carried until the subdivision was much more minute than in the others.

Tables V. and VI. give the results of experiments for the determination of the relative time required for the formation of an emulsion, when an excess of the agent had been used. In Table VII. the object was the determination of the amount of emulsifying agent necessary to form at once a permanent emulsion. In this series, solutions o different strength were used, in order that the same amount of fluid should be added in every case. It was agitated until a good emulsion had been formed.

TABLE V.

Solution used: Extractum Pancreatis, 1 per cent. 3 c.c. added at beginning of experiment, showing time required to emulsify the following samples which were used.

SAMPLE.	Time required for the formation of a permanent emulsion.	Time required for the formation of a complete emulsion.	
P (good butter), .	15 min.	45 min.	
R (good butter), .	15 "	45 "	
E (good butter), .	15 "	60 "	
O (cheap butter), .	35 "	–	A satisfactory complete emulsion not formed.
T (oleomargarine),	40 "	80 min.	
S (oleomargarine),	80 "	100 "	
U (oleomargarine),	90 "	120 "	
W (oleomargarine),	100 "	120 "	

TABLE VI.

4.5 c.c. of the 1 per cent. solution used, and added at once at beginning of experiment. First observation taken fifteen minutes after solution was added.

SAMPLE.	Time required for the formation of a permanent emulsion.	Time required for the formation of a complete emulsion.
P (good butter), ...	15 min.	15 min.
T (oleomargarine), ...	15 "	20 "
Q (oleomargarine oil), ...	90 "	–
C (cotton-seed oil), ...	90 "	–
D (lard), ...	25 "	90 min.
Y (lard), ...	15 "	60 "
Z (sesame oil), ...	60 "	120 "

At the end of two hours, Q, C and Z had not formed emulsions which could be fairly compared with the others, although they were uniformly broken up.

TABLE VII.

Solution of various strengths of Extractum Pancreatis used: $\frac{1}{4}$, $\frac{1}{2}$, 1, 2, 4, 8 and 12 per cent. 4 c.c. was added to the same amount as used in all previous experiments, and kept in the bath at the temperature of 40° C. for fifteen minutes, and then allowed to cool slowly, showing amount (by strength of solution) necessary to form permanent emulsion.

A (oleomargarine),	$\frac{1}{2}$ per cent.
S (oleomargarine),	1 "
Z (sesame oil),	8 "
M (oleomargarine oil),	12 "
C (cotton-seed oil),	12 "
G (lard),	1 "
Butter,	$\frac{1}{4}$ "

The accompanying plates, which are microphotographs of butter and oleomargarine in different degrees of emulsion, show better than description the relative conditions in this process, and are arranged in sets, that in each the two may be compared.

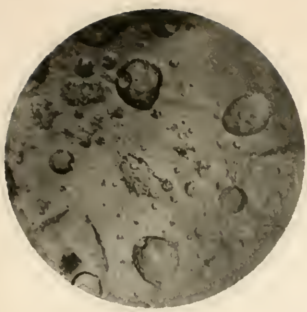
Figures 1 (butter) and 2 (oleomargarine) represent a partial emulsion, both under same conditions, showing the subdivision to be rather smaller with the butter.

Figures 3 (butter) and 4 (oleomargarine) show the same conditions, but carried further, and nearly approaching a permanent emulsion.

Figures 5 (butter) and 6 (oleomargarine) show the result of a sufficient quantity of emulsifying agent to form a permanent emulsion with butter, but not with oleomargarine. In the oleomargarine are some masses of fat not emulsified, which are not seen. The emulsion is not complete, and has not thickened, and there is therefore the tendency to spread, so that in both only scattered globules are seen.

Figures 7 (butter) and 8 (oleomargarine) represent a complete emulsion with both. In the previous ones, both were under the same conditions. These, however, were taken after the emulsion had become complete in each, and Fig. 8, therefore, represents a longer time and more of the emulsifying agent than 7. Many of the globules seen are smaller than in the case of the butter, but the closely and uniformly packed globules in Fig. 7 show a more favorable emulsion.

PLATE VI.



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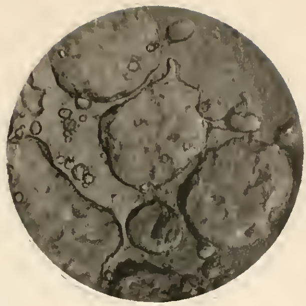

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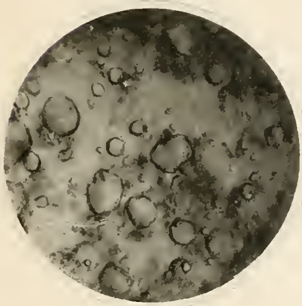

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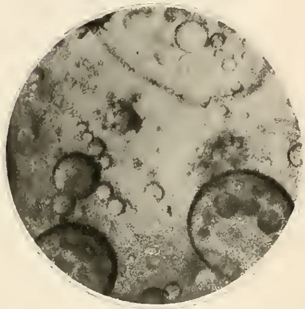

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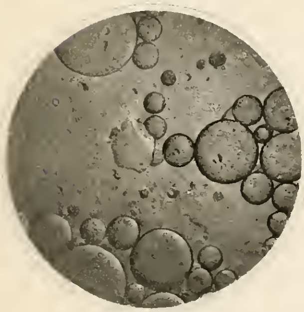

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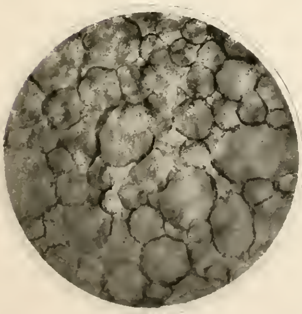
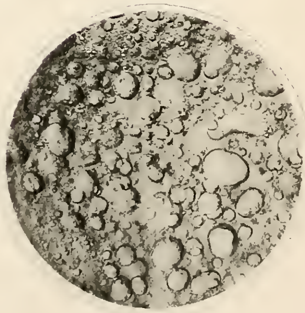


7



8

PHOTO. BY G. W. FITZ.

With the tables and figures to give results of these experiments, it may be superfluous to add the author's conclusions, as these may be had by reference to these data; but observations in the course of the experiments yield a more definite and more extensive evidence than can be expressed in figures. The evidence accords closely with the results of previous experiments of Von Meyer, Atwater, Rubner and others, in giving preference to butter in its digestion. With a scanty amount of an emulsifying agent, this is more apparent than with a sufficient quantity or an excess. There is but little difference in the way in which oleomargarine and butter break up into an emulsion, or in their appearance when agitated, except that the globules in the case of butter are somewhat finer; the difference is in the stability. How important this question of permanency of an emulsion may be, is, I think, difficult to determine, since during digestion the food is kept in constant motion.

Butter, however, forms a more uniform emulsion, as shown by Figures 7 and 8; or perhaps 3 and 4 will illustrate this point better, the butter being more uniformly affected, while in the oleomargarine, although some portions are as fine as the butter, others resist more and remain in larger masses. In oleomargarine, too, there is a certain amount of amorphous matter, even in the complete emulsions; this appears, under the microscope, very much like that seen in an emulsion of lard.

The minute subdivision does not take place with oleomargarine as readily as with butter, as is seen by reference to the tables in which the process was carried until subdivision was very fine, as in Tables III. and IV., and it is seen that the proportion used is somewhat larger.

One fact, which may present a suggestion, if nothing else, is the difference in the results with cotton-seed and sesame oils, as shown in Tables VI. and VII. The greater ease with which the latter formed an emulsion in the two experiments, was more striking than the results as expressed convey. It is regretted that this observation was made so late in this inquiry that there was no opportunity for following up this point more extensively and accurately; but, if this observation should be substantiated by subsequent in-

vestigation, this difference would be of some importance in a consideration of the digestibility of oleomargarine.

Therefore, as a food for the well, there is scarcely difference enough between butter and oleomargarine on grounds of digestibility to make it a matter of very much choice. However, all oleomargarines are not alike in this respect, as, for instance, compare L with S or T.

The above observations have been made with reference to a good butter alone, but when compared with a poor quality, the same does not hold; as is seen by results with O, which was a cheap butter, bought for twenty-five cents, while P and R were bought at the same time for thirty-five cents. The results with this poor quality of butter are no better than those obtained with oleomargarine, and in none of the attempts was an emulsion formed with it which equalled those with S and T or A. Therefore, between a poor butter and a good oleomargarine, the above statement as to slight preference would scarcely hold.

As a food for invalids, this difference is sufficient for careful consideration, especially when there is any digestive disturbance which involves pancreatic digestion, as the difference is more apparent when a limited amount of emulsifying agent is used, than when an excess is present.

The point that oleomargarine is an uncooked article, and therefore undesirable as food, has been raised, and perhaps deserves a passing notice. When, however, the object of cooking is considered, and the benefits which result are recalled, it is seen there is little ground for prejudice from this source. With meats, at least, there is scarcely any object, other than to produce a more agreeable flavor and to soften the connective tissue, that the soluble portions may be more easily separated in the digestive process. With the fats in oleomargarine this separation has already been effected by their process of extraction, and they consist, therefore, of the digestible portions alone, while the agreeable flavor is produced in another way.

Scientific men, and persons who, either from their occupation or otherwise, are fully acquainted with the subject and are qualified to judge fairly of the product, are quite unanimous in their favorable opinions of oleomargarine as a

healthful article of food. In the course of this inquiry, I have found but one, and that a strong opinion, that oleomargarine is of itself a good, healthful article of food, and much better than the poorer grades of natural butter.

In the report on food and food adulterants, Dr. Wiley quotes the opinions of many of the leading chemists, who unanimously give their opinion as to its wholesomeness, as the following abstracts from the reports * mentioned show.

Prof. C. F. Chandler says: —

I take the ground that there is nothing in any one of these materials in any sense unwholesome, and nothing in any one of them which makes it inferior as an article of food to dairy butter. I am perfectly familiar with the materials employed and the different processes, and know there is nothing whatever used either in material or process which is unwholesome, or in any way deleterious to the public health.

The following distinguished chemists, after carefully studying the manufacture, have made the most decided statements in favor of this new article of food: —

Prof. George F. Barker, University of Pennsylvania.
Dr. Henry A. Mott, Jr., New York.
Prof. G. C. Caldwell, Cornell University, Ithaca, N. Y.
Prof. S. W. Johnson, Yale College, New Haven, Conn.
Prof. C. A. Goessmann, Mass. Agricultural College, Amherst, Mass.
Prof. Henry Morton, Stevens Institute, Hoboken, N. J.
Prof. Charles P. Williams, Philadelphia, Pa.
Prof. W. O. Atwater, Wesleyan University, Middletown, Conn.
Prof. J. W. L. Arnold, University of New York.

I would further say that this question is one on which there is no difference of opinion among scientific investigators familiar with the chemistry of dairy products and fats. I have never seen a statement emanating from any person having any standing among scientific men, in which a contrary opinion is advanced.

* Bulletin 13, U. S. Department of Agriculture, Part I., 1887, pages 18-21.

Prof. G. F. Barker, University of Pennsylvania, says: —

I can see no reason why butterine should not be an entirely satisfactory equivalent for ordinary butter, whether considered from the physiological or commercial stand-point.

Prof. G. C. Caldwell, Cornell University (in reference to the oleo oil), declares: —

It is, when thus prepared, a tasteless and inodorous substance, possessing no qualities whatever that can make it in the least degree unwholesome when used in reasonable quantities as an article of food.

Prof. S. W. Johnson, Yale College, states: —

Oleomargarine butter has the closest resemblance to butter made from cream, in the external qualities, — color, flavor, and texture. It has the same appearance under the microscope, and in chemical composition differs not in the nature, but only in the proportions, of its components. It is, therefore, fair to pronounce them essentially identical.

Prof. C. A. Goessmann, Massachusetts Agricultural College, writes: —

A careful examination into the character of the material turned to account, as well as into the details of the entire management of the manufacturing operation, has convinced me that your product is made with care, and furnishes thus a wholesome article of food.

In the report of the Commissioner of Internal Revenue, 1887, are statements from collectors of districts in Pennsylvania, New York, Ohio, Illinois, Indiana and Colorado, comprising in all eleven districts. These reports are made from the returns of articles used as reported by the manufacturers of oleomargarine, as required by law, and from their familiarity with or investigation of the ingredients and processes used in the production of oleomargarine in the different factories in their districts.

The following list shows the various materials used, and was made from the monthly reports, and also from special reports from the collectors in whose districts oleomargarine factories are located.*

* P. 137.

Kind of Material.	No. of factories in which used.
Oleo, oleo oil,	31
Lard, leaf lard,	14
Cotton-seed oil,	10
Milk,	34
Salt,	37
Color — annotto; butter color,	37
Butter, dairy butter, creamery butter, natural butter,	31
Returned oleomargarine,	2
Neutral, neutral lard,	22
Salad oil,	10
Beef fat, beef oil,	6
Cream,	14
Glycerine,	2
Sugar,	3
Sesame oil,	5
Vegetable oil,	2
Old butter,	1
Butterine,	2
Buttermilk,	1
Nut oil,	1

The following are opinions expressed by the different collectors, in regard to its healthfulness: * —

E. A. Bigler, Collector, First District, Pennsylvania: —

I cannot learn that any substance deleterious to public health was used by this company in making their product.

Robt. Black, Collector, First District, New York: —

Great care is exercised by these parties not to allow any unfit article to be put on the market, and I am, therefore, safe in saying that oleomargarine, as made in this district, is a perfectly healthful article of food, and much purer than many other things now in our markets.

Frederick Gerker, Collector, Twenty-third District, Pennsylvania: —

. . . From the reports of the manufacturers, and the personal observation of my deputies, I am of the opinion that none of the ingredients used are deleterious to public health.

* Op. cit., p. 138.

Jas. W. Newman, Collector, Eleventh District, Ohio : —

I have inspected the factory of the above company, and found it cleanly, and free from unpleasant or noxious odors.

Jas. A. Hanlon, Collector, Twenty-eighth District, New York : —

The factory and all things appertaining thereto are as cleanly and sweet as any dairy in the country ; and, as far as this office has any experience, we do not hesitate to pronounce the oleomargarine produced at this establishment a good, pure and wholesome article, fit to be consumed by any person without the least injurious effect.

Jno. A. Sullivan, Collector, Second District, New York :

The above ingredients, separately or in combination, are not unwholesome or deleterious to public health.

As to their manipulations, these factories conducted their business in a cleanly manner, being fully as thorough in this respect as the average butter dairy or creamery ; and, as the end sought was the production of an article having a high commercial value, and the building up of a reputation for excellency in manufacture, they naturally used only pure, fresh and wholesome materials.

J. H. Farley, Collector, Eighteenth District, Ohio : —

I find the factories conducted with due care, as to cleanliness and quality of material used ; and, in so far as I have knowledge, I believe the oleomargarine thus far manufactured here to be as healthful, nourishing and clean as other oleaginous substances, whether naturally or mechanically combined.

R. Stowe, Collector, First District, Illinois : —

I cannot ascertain that there is anything used in this district in the manufacture of oleomargarine that can possibly be construed as being deleterious to the public health, either in itself or in the manipulation.

Wm. D. H. Hunter, Collector, Sixth District, Indiana : —

That the manufacturers do not use any other ingredients in the manufacture of oleomargarine than what they report on their form, No. 216 ; that the material used is clean and pure, and in his opinion the oleomargarine, as manufactured, is as healthful as butter of the best grades. (From report of the deputy.)

J. F. Benedict, Collector, District of Colorado: —

I have given the matter proper attention, and fail to discover that any substance deleterious to the public health is used in the manufacture of oleomargarine in my collection district.

The general opinions, as held by those having no special knowledge of the subject, or at least no other than a practical one, are perhaps of less importance than interest, but indicate the way oleomargarine is regarded by those having no other interest than consumers or disinterested parties. Many of these opinions were very positive, not only from the few who know something of it, but also from the many who have absolutely no knowledge of it.

Among those who possessed a practical knowledge of the subject, as a rule, very favorable opinions were held, and many used it in their homes. Inquiry made in all factories visited gave the same evidence, that, with very few exceptions, all employees used the oleomargarine.

By other people, who have no particular knowledge of the subject, at least no more than most of persons have about ordinary food, more or less prejudice is shown. This is partly based on misapprehension of the ingredients used (and this is usually so great as to be ludicrous), and partly because custom has so firmly installed the belief that, as butter is good for bread, therefore nothing else can be fit for such use.

RÉSUMÉ.

There was found no case in which substances were used which were not cleanly or wholesome; and it may also be added that no case of adulteration with unwholesome articles, in which the facts were well authenticated, has come to the author's knowledge, although search and inquiry have been constantly made. Stories of such as have been brought to notice have not stood the test of investigation.

The ingredients are those which find common use in many domestic ways, and in themselves, when of good quality, are wholesome, and in no way injurious when taken as food; and, as stated above, no grounds exist to reason that other than such quality is used. From these a mixture

is made by a process of manufacture which is simple, and which would in no way make an unhealthy compound. This product so nearly resembles butter in appearance and taste that experienced persons are not able to distinguish them with any degree of certainty.

Oleomargarine will resist rancidity longer than butter will under the same conditions.

The risk of parasites from the use of oleomargarine is one of possibility more than probability, and is one of those many risks which we are at present, of necessity, daily incurring, but from which we seldom suffer any tangible effects.

In nutritive principles, as shown by Prof. Atwater, it compares so favorably with butter as to present a difference almost too slight to be estimated, except by the chemist.

From the evidence we have of the digestion of the different fats, it would appear that there is a slight difference, and this in favor of butter. Such results are not conclusive of the actual digestion as accomplished by nature, but all agree in placing butter before oleomargarine, and also agree that this preference is slight.

Popular opinion in regard to oleomargarine is, in general, prejudiced, and, as has been said, is due in a great measure to mistaken ideas of its composition, and to the fact that, by people in general, it has been known and is still considered as adulterated butter. This term is rather an unfortunate one, and scarcely just, because of the universal revolt against anything with which this word is associated, without inquiry into its significance; and it would seem better to regard this product as a distinct article of food, since it is now legally recognized, and its manufacture is allowed.

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APPENDIX.

LAWS OF OTHER COUNTRIES.

ENGLISH MARGARINE ACT, 1887.

[CHAP. 29 — 50 AND 51 VICT.]

AN ACT for the better Prevention of the Fraudulent Sale of Margarine. [23d August, 1887.]

Whereas, It is expedient that further provision should be made for protecting the public against the sale as butter of substances made in imitation of butter, as well as of butter mixed with any such substances;

Be it therefore enacted by the Queen's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:

1. This Act may be cited as the Margarine Act, 1887.

2. This Act shall come into operation on the first day of January, one thousand eight hundred and eighty-eight.

3. The word "butter" shall mean the substance usually known as butter, made exclusively from milk or cream, or both, with or without salt or other preservative, and with or without the addition of coloring-matter.

The word "margarine" shall mean all substances, whether compounds or otherwise, prepared in imitation of butter, and whether mixed with butter or not, and no such substance shall be lawfully sold, except under the name of margarine, and under the conditions set forth in this Act.

4. Every person dealing in margarine, whether wholesale or retail, whether a manufacturer, importer, or as consignor or consignee, or as commission agent or otherwise, who is found guilty

of an offence under this Act, shall be liable on summary conviction for the first offence to a fine not exceeding twenty pounds, and for the second offence to a fine not exceeding fifty pounds, and for the third or any subsequent offence to a fine not exceeding one hundred pounds.

5. Where an employer is charged with an offence against this Act he shall be entitled, upon information duly laid by him, to have any other person whom he charges as the actual offender brought before the Court at the time appointed for hearing the charge, and if, after the commission of the offence has been proved, the employer proves to the satisfaction of the Court that he had used due diligence to enforce the execution of this Act, and that the said other person had committed the offence in question without his knowledge, consent, or connivance, the said other person shall be summarily convicted of such offence, and the employer shall be exempt from any penalty.

6. Every person dealing in margarine in the manner described in the preceding section shall conform to the following regulations: Every package, whether open or closed, and containing margarine, shall be branded or durably marked "Margarine" on the top, bottom and sides, in printed capital letters, not less than three-quarters of an inch square; and if such margarine be exposed for sale, by retail, there shall be attached to each parcel thereof so exposed, and in such manner as to be clearly visible to the purchaser, a label marked in printed capital letters not less than one and a half inches square, "Margarine"; and every person selling margarine by retail, save in a package duly branded or durably marked as aforesaid, shall in every case deliver the same to the purchaser in or with a paper wrapper, on which shall be printed in capital letters, not less than a quarter of an inch square, "Margarine."

7. Every person dealing in, selling, or exposing, or offering for sale, or having in his possession for the purpose of sale, any quantity of margarine contrary to the provisions of this Act, shall be liable to conviction for an offence against this Act, unless he shows to the satisfaction of the Court before whom he is charged that he purchased the article in question as butter, and with a written warranty or invoice to that effect, that he had no reason to believe at the time when he sold it that the article was other than butter, and that he sold it in the same state as when he purchased it, and in such case he shall be discharged from the prosecution, but shall be liable to pay the costs incurred by the prosecutor unless he shall have given due notice to him that he will rely upon the above defence.

8. All margarine imported into the United Kingdom of Great Britain and Ireland, and all margarine whether imported or manufactured within the United Kingdom of Great Britain and Ireland, shall, whenever forwarded by any public conveyance, be duly consigned as margarine; and it shall be lawful for any officer of Her Majesty's Customs or Inland Revenue, or any medical officer of health, inspector of nuisances, or police constable, authorized under section thirteen of the Sale of Food and Drugs Act, 1875, to procure samples for analysis if he shall have reason to believe that the provisions of this Act are infringed on this behalf, to examine and take samples from any package, and ascertain, if necessary, by submitting the same to be analyzed, whether an offence against this Act has been committed.

9. Every manufactory of margarine within the United Kingdom of Great Britain and Ireland shall be registered by the owner or occupier thereof with the local authority from time to time in such manner as the Local Government Boards of England and Ireland and the Secretary for Scotland respectively may direct, and every such owner or occupier carrying on such manufacture in a manufactory not duly registered shall be guilty of an offence under this Act.

10. Any officer authorized to take samples under the Sale of Food and Drugs Act, 1875, may, without going through the form of purchase provided by that Act, but otherwise acting in all respects in accordance with the provisions of the said Act as to dealing with samples, take for the purposes of analysis samples of any butter, or substances purporting to be butter, which are exposed for sale, and are not marked "Margarine," as provided by this Act; and any such substance not being so marked shall be presumed to be exposed for sale as butter.

11. Any part of any penalty recovered under this Act may, if the Court shall so direct, be paid to the person who proceeds for the same, to reimburse him for the legal costs of obtaining the analysis, and any other reasonable expenses to which the Court shall consider him entitled.

12. All proceedings under this Act shall, save as expressly varied by this Act, be the same as prescribed by sections twelve to twenty-eight inclusive of the Sale of Food and Drugs Act, 1875, and all officers employed under that Act are hereby empowered and required to carry out the provisions of this Act.

13. The expression "local authority" shall mean any local authority authorized to appoint a public analyst under the Sale of Food and Drugs Act, 1875.

German Law on Butter Substitutes, Approved July 12, 1887.

Section 1. The business rooms and other selling and market places at which "margarine" is sold or placed on sale shall show prominently the distinct indelible sign, "sale of margarine." "Margarine" within the meaning of this act shall be those preparations similar to milk butter, the fatty contents of which are not exclusively derived from milk.

Sect. 2. The admixture of butter with margarine or other table fats for the purpose of carrying on trade in those admixtures, as well as in dealing in or placing the same on sale, shall be prohibited. This provision shall not apply to the admixture of milk and cream in the preparation of margarine: *provided, however*, that no more than one hundred parts of milk in weight, or ten parts of cream in weight, in one hundred parts in weight of fats not derived from milk, shall find application.

Sect. 3. The vessels and wrappings in which margarine is sold or offered for sale, shall show prominently a distinct and indelible label which contains the word "margarine." If margarine is sold or offered for sale in whole kegs or cases, such label shall also contain the name or the firm of the manufacturers. When sold at retail, margarine must be delivered to the buyer in a wrapper on which is printed the word "margarine," and the name or firm of the seller. If margarine is sold or offered for sale in regularly formed pieces, the same must be in the shape of cubes, bearing the above label, if they are not provided with a wrapper showing such label. The Federal Council shall have the right of executing the provisions in clauses 1–3 to issue orders to be published in the bulletin of laws of the Empire.

Sect. 4. The provisions of this act shall not apply to such productions described in section 1 as are not intended for human consumption.

Sect. 5. Violation of the provisions of this act, as well as of the orders of the Federal Council, to be issued in conformity with section 3, shall be punished by a fine not exceeding one hundred and fifty marks ($36), or by imprisonment. For a second offence, a fine of not more than six hundred marks ($144), or imprisonment for not more than three months, shall be imposed.

This provision shall not apply in cases where a period of three years has elapsed since an offender had paid a fine, or such fine had been remitted.

In addition to the penalty, confiscation of such articles as are sold or offered for sale can be made, whether said articles belong or do not belong to the convicted parties.

If a prosecution or conviction of any party is not practicable, confiscation of goods may be made without regard to ownership.

Sect. 6. The provisions of the act relative to the traffic in articles of food consumption and in general domestic use, of May 14, 1879 (Reichs-Gesetz-Blatt, p. 1451), shall not be affected. The provisions in sections 16 and 17 of the same shall apply also in case of violation of the provisions of the present act.

Sect. 7. The present act shall take effect on the 1st of October, 1887.

Publication of the Chancellor of the German Empire relative to Provisions to carry out the Act touching the Traffic in Substitutes for Butter, July 26, 1887.

To carry out the provisions contained in section 3, clauses 1 and 3, of the act in relation to the traffic in substitutes for butter, of July 12, 1887, the Federal Council, in conformity with section 3, clause 4, of this act, has adopted the following regulations and rules: —

(1.) For the marking (as prescribed by section 3, clause 1, of the act relative to the traffic in substitutes for butter, July 12, 1887) of the vessels and exterior coverings in which margarine is sold or offered for sale, the inclosed pattern shall be taken as a model, provided that the length of the frame surrounding the label shall be no greater than five times its height, and is no less than thirty centimeters and no more than fifty centimeters.

(2.) The name of the firm or of the manufacturer (section 3, clause 2, of the act) shall be placed immediately over, under, or by the side of the said label.

(3.) The label (clauses 1 and 3) shall be attached by branding or painting. In the latter case it must be made with black colors on white or light-yellow ground. Up to the 1st of April, 1888, it shall be permitted to use printed labels, to be pasted on.

(4.) The label (sections 1 and 2) shall be placed on the sides of the vessels in at least two opposite places; in case of vessels having a cover, it shall be placed also on the upper surface of the cover, and in the case of casks, kegs, and the like, upon the bottoms.

(5.) The requirements of sections 1 and 2, within the meaning of this act, shall apply to the wrappers used in the sale of margarine at retail (section 3, clause 3), provided that the length of the framing shall not be less than fifteen centimeters.

(6.) For the marking of the cube-shaped pieces (section 3, clause 3), it is provided that there shall be no restrictions as to the

size of the framing, and that it shall be permitted to divide the word "margarine" into halves, to be placed one under the other, and to be connected by hyphens.

VON BOETTICHER.

Coloring Oleomargarine. — Consul Mealey, of Munich, transmits the following: —

The subject of a law concerning the trade in oleomargarine was referred to a commission of twenty-eight, who have finished their investigations and consultations. The examinations which were made are rather favorable for the use of oleomargarine, and the health department has already acknowledged the value of their conclusions, published on the 22d of March, 1887, concerning oleomargarine. That report says: This product is made in great part from such proper ingredients as are useful in nourishment, namely, the fats or greases; and therefore it is of importance, as it furnishes to the poorer classes a substitute for butter which is cheaper and at the same time nourishing. We think that this want has been supplied in a most satisfactory manner by the manufacture of artificial butter. And it is offered in the markets in a condition superior to natural butter as far as cleanliness and careful preparation are concerned. Although we can agree with the judgment of the Royal Health Department that oleomargarine is a desirable addition to the food supply, yet the object of the law about the traffic in oleomargarine is to be commended, viz., to abolish the extended adulteration of natural butter with oleomargarine. To accomplish this many propositions have been made about the coloring of oleomargarine so that it will be impossible to substitute oleomargarine for natural butter. In this connection a discovery made by Dr. Fr. Soxhlet, professor in the Technical High School and chief of the Agricultural Experimental Station in Munich, is particularly interesting. Starting with the idea that any intense coloring-matter would cause a deterioration in oleomargarine, both in delicacy and in nourishing qualities, Professor Soxhlet proposes to add a harmless substance in small quantity which shall in no way change the color, taste, or smell, or usefulness of oleomargarine, but which, while it cannot be removed from the oleomargarine, will yet furnish every one with an easily applied test, so that if only one-tenth of the mixture is oleomargarine it can be at once discovered. The professor recommends as such a substance phenol phtalein, one gram for one hundred kilograms of oleomargarine.

A piece of oleomargarine as large as a pea, treated thus with

the phenol phtalein, if put on a plate with a drop of common household lye, soda, potash, or ammonia, and rubbed together well, will immediately give out an intense bright-red color. A little cigar ashes made wet, rubbed with the oleomargarine, and pressed between folds of white blotting-paper, shows a red spot on the blotting-paper. The lye and ammonia give a more intense and lasting red color. The test is as simple as the well-known litmus-paper test.

Every market-master can make hundreds of such examinations in a short time, and every consumer is furnished with an easy and infallible test.

This manner of preparing the oleomargarine with the phenol phtalein does not affect the artificial butter at any stage of its manufacture, or at any time in its use. The color never comes out uncalled for, and in preparing meals it does not come in contact with strong alkalies, and so does not discolor.

By this new discovery the principal reasons for the prohibition of the manufacture of oleomargarine have been removed.

Danish Artificial Butter Bill.

1. Whoever manufactures artificial butter must produce a written account of the mode of manufacture, and must expose for sale the final product in vessels, the form of which is entirely different from that of the firkins in which butter is usually sold. These vessels must be marked with the word "margarine," in accordance with the instructions issued by the Minister of the Interior.

2. Those who engage either in the wholesale or retail trade in artificial butter must keep their goods in special vessels. The trade in artificial butter must be carried on in places only which are distinctly indicated by the Minister as places where "margarine" may be sold. No genuine butter may be sold in such places. Packages containing margarine must be plainly marked accordingly. No trade in artificial butter may be carried on in markets or from ships.

3. The export of artificial butter in vessels other than those specially made to contain this kind of goods is punished by imprisonment.

4. Importation of the same is also punishable.

5. All documents describing artificial butter shall speak of it as "margarine."

6. The manufacture, sale, importation, or exportation, of any mixture of butter with artificial butter, oleomargarine, or hog's lard, is punishable with imprisonment.

7. It is forbidden, under penalty, to manufacture, sell, export, or import, artificial butter which has the usual color of dairy butter.

8. A staff of inspectors is appointed to see that the articles of this law are carried out in Copenhagen and in the provinces.

9. The inspector shall have the right at any time to enter a manufactory of artificial butter, to test the product, and to examine the written description of the mode of manufacture described in section 1.

10. The Ministry of the Interior will appoint a chemical staff to aid the inspectors in their work.

This law took effect May 1, 1887.

Regulations Affecting the Sale and Exportation of Artificial Butter in Norway.

"*Post och Inrikes Tidningar*" *of Dec. 30, 1886.*

Each vessel must be marked on its sides with two stamps of the form and size given in a drawing appended to the decree. This drawing consists of the word "margarin" in large letters contained within an oval ring. The stamps, which are placed opposite each other close to the top of the vessel, are to be branded into wooden vessels, and on vessels of other material painted plainly in permanent black color. This decree takes the place of that published on the 20th of November, 1886.

The New French Butter and Oleomargarine Law.

[March 14, 1887.]

Section 1. The repression of frauds in the sale of butters.

Article 1. It is forbidden to expose or place in the market for sale, to export or to import under the name of butter, margarine, oleomargarine, and, in general, any substance intended as a substitute for butter, including compounds of margarine, fat, oil, and other substances with butter, irrespective of the quantity used in the mixture.

Art. 2. Any violation of article 1 is punishable by an imprisonment of from six days to six months, and by a fine of from fifty to three thousand francs. Concealment of the name of the maker or vendor is to be construed as wilful sale.

Art. 3. Substances or compounds fraudulently exposed, sold, offered for sale, imported or exported, remaining in the possession

of the manufacturer, shall be confiscated, in accordance with article 5 of the law of the 27th March, 1851.

Art. 4. The courts may order that any convictions under article 2 shall be published in any newspapers which they may indicate, or posted up in the places or markets where the offence was committed, as well as on the doors of the house or warehouse of the offender, and also on those of the offices of the mayor of the town in which the offender is resident, the expenses in each case to be borne by the delinquent.

Art. 5. On a repetition of the offence within a year following the first conviction the maximum fine will always be inflicted, and the judgment always published and placarded.

Sect. 2. The sale, transport, and exportation of margarine, oleomargarine, or edible fats.

Art. 6. Every retail dealer in margarine, oleomargarine, or any substances or compounds intended to imitate butter, must inform the intending purchaser that the substance or compound sold by him is not butter, by delivering it in a vessel or wrapper having a legible label, stating that the article is "margarine, oleomargarine, or edible fat."

Art. 7. Every manufacturer, wholesale dealer, or consignor of margarine, oleomargarine, or similar substances, shall be obliged to place them in casks or receptacles marked in large characters, printed or branded, with the words "margarine, oleomargarine, or edible fats."

Art. 8. The manufacturers, dealers, exporters, or consignors of margarine, oleomargarine, or similar substances, must clearly indicate upon the invoice, way-bill, bill of lading, etc., for each consignment of goods of this description, that the articles so forwarded are sold as margarine, oleomargarine, or edible fat.

Every carrier and carrying company by land or water must have this description of goods marked in their books, invoices, and declarations or manifests.

Russia.

1. The product obtained from a mixture of fat with butter shall be called margarine fat.

2. Its manufacture shall be liable to an excise duty, or to supplementary patent dues.

3. The extent of the impost shall be determined in concert by the Ministers of Finances and Imperial Domains.

4. Margarine fat shall be dyed some bright color, but in no case shall such color be yellow.

5. The vessels [cases, firkins] in which margarine is packed at the manufactory shall be dyed the same color as the margarine.

6. These vessels shall have clearly marked on them the name of the manufactory and they shall also bear the inscription "margarine fat."

7. The sale of margarine fat shall not be carried on in the shops where dairy butter is on sale.

8. Shops dealing in margarine fat shall exhibit a signboard bearing an inscription that margarine fat is sold within.

9. Hotels, cook-shops, restaurants, bars, and, in general, all public establishments in which food is prepared, shall exhibit in a conspicuous place a notice, and shall also state on their bills of fare, that the dishes prepared on the premises are cooked with margarine, if such be used by them in their kitchen.

10. The importation of margarine fat from foreign countries shall be prohibited.

St. Petersburg, June 7, 1887.

SUMMARY

OF THE

WEEKLY MORTALITY REPORTS

OF

MASSACHUSETTS CITIES AND TOWNS.

THE

WEEKLY MORTALITY REPORTS OF MASSACHUSETTS CITIES AND TOWNS FOR THE YEAR 1887.

The following summary is compiled from the returns of deaths which are forwarded to the office of the State Board of Health by the registrars or boards of health of cities, and by the town clerks of such towns as are willing to contribute this information. This work has been continued for a succession of years, and has been published in the form of a weekly bulletin by the State Board, — one copy having been sent to each city and town during each week in the year. A summary of the same has also been furnished for publication to the "Boston Journal" every week.

The report is a partial one only, and includes the statistical data of a portion only of the State, the part which returns no report consisting mainly of the smaller towns, in which the system of registration is not as thoroughly and as promptly carried out as in the cities.

The average estimated population of the cities and towns represented in this report, for the year 1887, was about 1,100,000. Any such estimate of population becomes more and more unreliable, in proportion to the number of years which has elapsed since the taking of a census of the population.

The method of estimating population, employed in the making up of this report, is that which is commonly used in most countries at present in the intervening years between the census periods. The rate of increase is assumed to be the same from 1885 (the date of the last State census) to the middle of the year 1887, as that which had prevailed for the ten years previous.

General Summary.

DATE.	Barometer.	Maximum Thermometer. Mean for ea. week.	Minimum Thermometer. Mean for ea. week.	Rain — Inches.	Humidity. Mean for ea. week.	Total Deaths.	Deaths under 5.	Infectious Diseases.	Consumption.	Acute Lung Diseases.	Typhoid Fever.	Diarrhœal Diseases.	Scarlet-Fever.	Measles.	Diphtheria and Croup.	Puerperal Fever.	Whooping-Cough.	Malarial Fever.	Small-pox.	Erysipelas.	Death-rates per 1,000.
1887.																					
Jan. 8, ...	30 258	27.4	14.7	.63	68.4	465	176	65	66	85	8	4	5	7	26	-	6	-	-	1	22.61
15, ...	29.844	30.	10.	.93	72.4	441	134	55	69	71	5	9	3	3	30	-	1	-	-	1	22.02
22, ...	29.964	29.	12.	.67	74.	364	106	37	75	54	1	2	-	1	25	2	-	-	-	4	20 74
29, ...	30.070	34.2	13.4	2.06	75.9	446	132	40	54	77	4	7	3	2	17	-	-	-	-	2	22.45
Feb. 5, ...	30.371	46.6	21.1	.72	72.4	369	109	45	55	56	9	8	2	5	14	2	-	-	-	1	18,95
12, ...	30.061	41.	23.	.67	73.	438	143	51	66	64	7	6	-	3	26	2	1	-	1	2	20.89
19, ...	30.125	42.	23.	1.47	69.8	398	115	42	67	76	6	6	2	5	13	2	3	-	-	-	20.52
26, ...	30 185	35.	23.	.79	67.	448	138	46	70	61	12	-	2	7	19	-	1	-	-	1	20.68
March 5, ...	30.096	34.	17.	.12	34.	450	143	56	54	78	9	5	4	7	25	1	1	-	-	2	18.55
12, ...	30.016	38.	25.	1.80	76.	438	129	40	66	67	6	3	1	6	16	3	1	-	-	1	20 27
19, ...	29.464	42.	27.	.15	68.	508	133	50	68	73	10	6	4	8	11	2	1	-	-	-	22.68
26, ...	29.736	41.	27.	.55	66.	526	164	48	78	77	6	8	2	10	12	-	5	-	-	1	23.72
April 2, ...	29.920	33.	23.	1.59	66.	482	158	43	95	77	3	8	2	10	12	-	1	-	-	-	22 22
9, ...	30.123	50.	29.	.03	56.	445	129	37	70	70	6	5	3	7	11	1	-	-	-	-	21.95
16, ...	30.060	54.	38.	.46	56.	452	122	41	73	72	6	5	3	7	12	4	3	-	-	-	22,18
23, ...	29.956	51.	35.	.36	59.	533	177	74	67	89	9	5	3	23	17	-	4	-	-	3	24.38
30, ...	29.675	51.1	42.5	1.54	71.	418	391	38	69	52	11	1	4	6	10	-	1	-	-	-	22.44
May 7, ...	30.306	67.	49.	.12	63.	418	115	38	56	69	11	5	4	6	10	-	1	-	-	-	22.46
14, ...	30.137	68.	51.	.10	53.3	418	116	47	67	80	7	6	10	3	14	-	1	-	3	1	20.15
21, ...	30.066	69.	52.	-	43.6	421	115	53	83	64	-	7	6	12	15	-	2	-	-	2	21.12
28, ...	29.824	72.	57.	1.42	81.6	450	146	56	58	55	7	6	9	14	14	-	2	-	-	-	19.87
June 4, ...	30.049	60.	51.	1.11	89.	417	115	62	66	43	9	5	8	12	21	-	-	-	-	2	16.14
11, ...	30.076	71.	53.	-	72.4	425	109	48	87	32	9	5	2	11	14	3	2	-	-	1	18.79
18, ...	29.958	63.	56.	-	61.6	344	114	46	62	32	5	12	2	9	11	-	4	-	-	2	17.43
25, ...	29.913	75.	61.	.90	78.9	365	113	49	68	31	4	8	2	14	16	1	1	-	-	1	17.66
July 2, ...	30.148	84.	75.	-	60.3	380	133	54	50	12	2	23	3	11	7	-	6	-	-	-	21.30
9, ...	29.974	85.	80.	.01	72.9	529	333	133	60	20	4	96	-	13	5	-	5	-	-	1	27.12
16, ...	29.847	80.	64.	1.15	68.6	520	255	192	71	24	8	159	6	2	9	-	6	-	-	-	26.37
23, ...	30.001	74.	65.	2.02	88.3	583	313	221	02	12	4	195	-	6	5	-	6	1	-	-	27.41
30, ...	30.002	84.	67.	.40	80.6	714	392	311	64	17	9	271	2	10	7	-	3	-	-	1	32.86

Aug 6,	29.976	79.	67.	.51	83.6	574	335	235	47	11	7	209	2	1	10	–	4	–	–	–	30.01
13,	30.034	78.	61.	.24	61.	625	327	183	60	23	16	183	1	–	7	–	9	–	–	–	27.83
20,	29.870	78.	61.	.64	62.	590	264	182	67	17	8	150	5	3	13	–	5	–	–	–	27.05
27,	29.840	72.	57.	1.66	77.6	515	213	171	57	12	21	111	2	2	17	1	8	–	–	–	21.60
Sept. 3,	30.090	69.	53.	–	76.	471	209	147	59	22	23	90	4	–	15	–	7	2	–	–	22.78
10,	29.980	75.	59.	.67	79.	515	214	123	73	26	20	70	3	–	14	1	7	1	–	–	24.29
17,	30.200	66.	52.	.20	78.6	436	165	136	56	25	23	48	7	1	15	–	7	–	–	–	22.04
24,	30.080	67.	49.	.05	67.	507	188	113	73	32	23	43	8	3	22	1	7	–	–	–	23.31
Oct. 1,	30.070	60.	49.	.70	80.	445	138	107	60	30	25	37	10	–	21	–	4	–	–	–	19.26
8,	29.823	69.	52.	.15	82.	435	159	64	62	51	16	27	6	–	21	–	1	1	–	–	20.71
15,	29.960	59	45.	.76	74.4	427	142	84	46	23	8	28	11	–	32	1	1	–	–	–	18.93
22,	29.999	59	43.	.97	76.7	448	125	78	68	33	14	15	9	1	31	1	–	–	–	1	19.82
29,	30.560	51.	39.	Trace	73.9	425	132	73	74	39	14	12	15	1	24	–	1	–	–	–	21.27
Nov. 5,	29.974	51.	33.	–	66.4	405	124	73	62	42	18	17	16	–	23	–	1	–	–	–	20.42
12,	29.864	54.	34.	.82	61.6	434	139	83	63	56	10	14	18	–	35	–	–	–	–	–	20.85
19,	29.769	49.	35.	1.14	77.1	482	150	82	74	85	10	9	20	2	33	2	1	–	–	–	21.90
26,	30.150	49.	34.	–	85.9	471	140	85	57	68	12	10	25	–	32	2	1	–	–	–	21.41
Dec. 3,	30.550	43.6	32.8	.15	84.	448	126	80	61	66	11	6	19	–	37	2	2	–	–	2	22.08
10,	30.251	44.	33.	.11	80.4	430	135	65	65	53	6	4	16	1	30	2	1	–	–	2	21.50
17,	29.944	49.	32.	1.11	76.4	440	113	62	68	50	3	6	10	–	34	3	1	–	–	4	21.14
24,	29.763	39	25.	.48	76.6	422	141	82	60	55	7	4	27	2	33	2	4	–	–	1	20.18
31,	30.033	29.	14.	1.03	77.1	510	167	66	68	64	7	6	16	–	49	1	1	–	–	3	23.12
Total,	–	–	–	–	–	24,060	8,814	4,462	3,396	2,582	502	1,955	347	257	992	43	141	5	4	43	–
Weekly average,	–	–	–	–	–	463	169.5	85.8	65.3	49.6	9.65	38.1	6.7	4.94	19.1	.83	2.71	.096	.077	.827	–
Ratio per 1,000 deaths,	–	–	–	–	–	–	366.3	185.37	141.1	107.3	20.86	82.50	14.42	10.63	41.2	1.79	5.86	.21	.17	1.79	–

Estimated average population per week of reporting cities and towns, ... 1,083,169

The data embraced in this report are as follows : —

Average height of barometer for each week.	Deaths from Consumption.
Mean of daily maximum temperature.	Acute lung diseases.
Mean of daily minimum temperature.	Typhoid fever.
Rainfall expressed in inches.	Diarrhœal diseases.
Humidity.	Scarlet-fever.
Total deaths for each week reported.	Measles.
Deaths of children under five years.	Diphtheria and croup.
Deaths from infectious diseases.	Puerperal fever.
	Whooping-cough.
	Malarial fever.
	Small-pox.
	Erysipelas.

Total Deaths.

The whole number of deaths reported for the year 1887, from the cities and towns which contributed returns, was 24,060, and the average number per week was 463.

The greatest number of deaths reported in one week was 714 for the week ending July 30 (the greatest number reported in 1886 was in the corresponding week of that year), and the least number reported was 344 for the week ending June 18 (the least number in 1886 being reported for the week ending June 12).

The weekly average number of deaths reported for each month was as follows : —

January,	429	July,	540
February,	413	August,	576
March,	481	September,	482
April,	466	October,	436
May,	427	November,	448
June,	388	December,	450

The months in which the greatest number of deaths was reported were July and August, and those in which the least number was reported were June and February.

Of the 24,060 deaths reported, the percentages of mortality in the different quarters of the year were as follows: —

	First quarter per cent.	Second quarter per cent.	Third quarter per cent.	Fourth quarter per cent.
Total deaths, . . .	21.99	23.23	28.92	25.86
Deaths under five, . .	21.78	18.40	37.91	21.91

Deaths under Five Years.

The number of deaths of persons under five years of age reported was 8,814, and the weekly average for the year 169.

The greatest number reported in any week was 392 for the week ending July 30, and the least number 106 for the week ending January 6.

The ratio of reported deaths of persons under five years of age to the total number of deaths was 36.6 per cent., or one in 2.73, which was considerably greater than that of 1886 — 33.9.

The average weekly number of reported deaths of children under five years of age for each month was as follows:—

January, ...	137	July, ...	285
February, ...	126	August, ...	285
March, ...	142	September, ...	194
April, ...	195	October, ...	139
May, ...	123	November, ...	138
June, ...	113	December, ...	136

The months in which the greatest number of deaths of children under five years of age was reported were July and August, and those in which the least number was reported were May and June.

Consumption.

The reported number of deaths from consumption was 3,396, and the weekly average for the year was 65.

The average weekly number of deaths reported from this disease for each month was as follows : —

January,	66	July,	61
February,	64	August,	58
March,	66	September,	65
April,	75	October,	62
May,	66	November,	64
June,	71	December,	64

The months having the greatest number of reported deaths from consumption were April and June, and those having the least number were July and August.

The ratio per thousand of reported deaths from all causes was 141.1, that of 1886 being 156.5.

Acute Lung Diseases — Pneumonia, Bronchitis, Asthma and Pleurisy.

The number of deaths reported from acute lung diseases was 2,582, and the weekly average was 50.

The average weekly number of deaths reported for each month was as follows : —

January,	72	July,	19
February,	64	August,	16
March,	74	September,	26
April,	72	October,	35
May,	67	November,	63
June,	34	December,	59

The months having the least number of reported deaths from acute lung diseases were July, August and September, and those having the greatest number were January, March and April.

The ratio per thousand deaths from these diseases was 107.3 ; for the previous year it was 102.4.

Typhoid Fever.

The number of reported deaths from typhoid fever was 502, and the weekly average 9.6.

The average weekly number of deaths reported in each month was as follows: —

January,	4	July,	5
February,	8	August,	14
March,	8	September,	22
April,	7	October,	16
May,	6	November,	12
June,	7	December,	7

The months having the greatest number of reported deaths from this disease were August, September and October, and those having the least number were January and May.

Two-thirds of the reported deaths from this cause occurred in the last half of the year.

The ratio per thousand deaths from all causes was 20.9, which was greater than that of either 1885 or 1886, and less than that of 1884.

Diarrhœal Diseases (including Diarrhœa, Dysentery, Cholera Infantum, Cholera and Enteritis).

The number of deaths reported from this class of diseases was 1,985, and the weekly average was 38.1.

The average weekly number of deaths in each month was as follows: —

January,	5	July,	149
February,	5	August,	163
March,	6	September,	63
April,	5	October,	24
May,	6	November,	12
June,	7	December,	5

The months having the greatest number of reported deaths from these diseases were July, August and September, and those having the least number were January and February.

The mortality from these diseases in the last half of the year was 92.8 per cent. of the whole number reported for

the year, and for the three months of July, August and September it was 78 per cent. The ratio of reported deaths to the total reported mortality was 82.5 per thousand, as compared with 77.2 in 1886, 76.1 in 1885 and 89.4 in 1884. The reported mortality of the United States for the census year 1880, from these diseases, was 86.6 per thousand of the total mortality.

Scarlet-Fever.

The whole number of deaths reported from scarlet-fever was 347, and the weekly average was 6.7.

The weekly average mortality in each month was as follows: —

January,	3	July,	3
February,	1	August,	2
March,	3	September,	5
April,	3	October,	10
May,	7	November,	20
June,	3	December,	18

The months having the least number of reported deaths were February and August; those which had the largest number were November and December.

Nearly two-thirds of all the deaths reported from this disease occurred in the last quarter of the year.

The ratio of deaths reported from scarlet-fever, to the mortality reported from all causes, was 14.4 per thousand, which was greater than that of the preceding year, but was also less than that of 1883, 1884 or 1885, and also less than that of the twenty years, 1861 – 1880.

Measles.

The whole number of deaths reported from measles was 257, and the weekly average 4.9.

The average weekly mortality from this disease for each month was as follows: —

January, ...	3	July, ...	8
February, ...	5	August, ...	1
March, ...	8	September, ...	1
April, ...	11	October, ...	1
May, ...	9	November, ...	–
June, ...	12	December, ...	1

The months in which the greatest number of deaths was reported from measles were April and June. Nearly four-fifths of the reported deaths occurred in the first half of the year.

The ratio of reported deaths from this cause to the total mortality was 10.7, which was greater than that of either 1884, 1885 or 1886, and very nearly the same as that of 1883.

Diphtheria and Croup.

The total number of deaths reported from these diseases was 992, and the weekly average was 19.1.

The average weekly mortality reported for each month was as follows:—

January, ...	24	July, ...	6
February, ...	18	August, ...	12
March, ...	16	September, ...	16
April, ...	12	October, ...	26
May, ...	13	November, ...	31
June, ...	15	December, ...	37

The months in which the least number of deaths from these diseases was reported were April, May, July and August, and those in which the greatest number was reported were October, November and December.

As compared with the total mortality the reported deaths from these diseases were 41.2 per thousand, which was slightly less than that of either of the four preceding years, and also considerably less than the average of the ten years, 1871–1880.

Whooping-cough, Erysipelas, Puerperal Fever, Malarial Fever and Small-pox.

The reported deaths from these diseases were as follows: —

	Total deaths reported.	Weekly average.
Whooping-cough,	141	2.7
Erysipelas,	43	0.8
Puerperal fever,	43	0.8
Malarial fever,	5	0.1
Small-pox,	4	0.08

The ratio of reported mortality from these diseases per thousand of the total mortality was as follows: —

Whooping-cough,	5.8
Erysipelas,	1.7
Puerperal fever,	1.7
Malarial fever,	0.2
Small-pox,	0.16

The reported mortality from whooping-cough was slightly greater than that of 1886, that from puerperal fever was also greater and that from erysipelas a little less than that of the previous year.

Small-pox.

The principal facts relative to this disease, so far as it has affected the population of the State during the past year, are detailed in the General Report (pages xvi–xxv). The total number of cases reported to the Board was thirteen, of which four were fatal. Of the thirteen cases, nine occurred in towns in which paper mills are located, and the victims were either operatives in such mills or were members of the families of such operatives.

For the more thorough prevention of this disease, certain measures are desirable.

1. A strict enforcement of the laws relative to the vaccination of operatives employed by manufacturing corporations and other similar establishments.

2. Careful inspection of all recently vaccinated persons within one week after vaccination. If the vaccination is not successful, re-vaccination should be performed. It should be remembered that want of success is oftener due to the age of the virus employed than to the insusceptibility of the person vaccinated.

3. As a measure of isolation, it is especially desirable that towns in which paper mills are located should have pest-houses or hospitals for the proper segregation and treatment of the sick.

4. The sale of infected clothing, bedding, rags, or other infected articles, should be made a crime, as it is now in England.

Malarial Fever.

This disease has nearly disappeared from the western part of the State, and its prevalence during the past year has been limited chiefly to the towns of Framingham and Natick, and the region immediately adjoining those towns. Since it is rarely fatal, its results have but little influence upon the mortality returns. The number of deaths reported to the Board during the year was but nine, of which four were in the Connecticut valley.

One occurred in Chicopee, one in Springfield, two in West Springfield, two in Boston, one in Newton, one in Lawrence and one in Worcester.

One death was reported in February, one in May, two in July, three in September, one in October and one in November.

Mortality-rates of Cities.

In the following tables are presented the mortality rates of the cities of the State for each week in the year, in accordance with the custom which has been followed during the past three years.

These mortality rates must necessarily be estimated, since the census of the cities for which such estimates are made is

taken but once in five years, and the estimates must consequently be more or less inaccurate, such want of accuracy being in proportion to the number of years which has elapsed since the taking of a census.

The method of estimating populations is based upon the rate of increase for the previous ten years, this method being found to give more accurate results, as a general rule, than the method of computation on the basis of assessed polls.

Mortality-rates of Cities.

	Boston.	Worcester.	Lowell.		Boston.	Worcester.	Lowell.
Jan. 8,	27.57	12 92	33.28	July 9,	34.53	24.82	39.50
15,	26.51	22.84	24.35	16,	27.70	26.28	32.39
22,	23.31	21.28	33.18	23,	30.98	21.17	29.23
29,	27.17	18.24	24.35	30,	37.94	16.06	35.55
Feb. 5,	22.64	11.40	30.04	Aug. 6,	34.14	16.79	45.03
12,	21.58	20.52	46.27	13,	30.12	18.25	34.76
19,	25.17	24.09	33.28	20,	27.97	24.09	40.29
26,	20.91	15.20	30.04	27,	27.18	19.18	25.28
March 5,	11 59	16.75	23.54	Sept. 3,	27.06	21.22	24.49
12,	22.91	12.84	24 35	10,	26.78	21.17	36.34
19,	25.71	19.76	27.60	17,	23.90	18.25	18.96
26,	26.51	19.76	46.27	24,	25.21	17.52	30.02
April 2,	25.71	10.64	28.41	Oct. 1,	23.11	12.41	16.59
9,	27.30	17.48	42.66	8,	23.89	21.17	18.17
16,	25.04	20.25	33.97	15,	21.66	18.25	22.12
23,	27.04	22.80	37.34	22,	26.26	12.41	18.17
30,	25.44	15.96	26.07	29,	25.34	21.90	31.60
May 7,	25.71	13.50	33.97	Nov. 5,	25.99	16.79	16.59
14,	22.91	12.16	31.66	12,	25.47	13.87	25.28
21,	24.24	12.16	30.85	19,	24.95	16.79	25.28
28,	24.77	12.16	32.66	26,	24.82	14.60	18.16
June 4,	17.33	14.60	18.96	Dec. 3,	25.87	19.71	31.60
11,	22.98	10.22	24.94	10,	24.82	16.79	16.59
18,	18.12	20.44	28.65	17,	27.30	11.68	18.17
25,	19.96	14.60	17.38	24,	22.58	18.98	19.75
July 2,	22.71	21.17	31.86	31,	28.09	16.06	23.70

Population of Boston (estimated),	401,480
Total deaths,	10,071
Death-rate for 1887 (estimated),	25.08
Population of Worcester (estimated),	73,682
Total deaths,	1,464
Death rate, 1887 (estimated),	19.87
Population of Lowell (estimated),	67,851
Total deaths,	1,868
Death-rate, 1887 (estimated),	27.53

Mortality-rates of Cities.

	Cambridge.	Fall River.	Lynn.		Cambridge.	Fall River.	Lynn.
Jan. 8, . .	18.69	22.94	24.86	July 9, . .	22.95	34.75	15.18
15, . .	19.58	25.59	10.17	16, . .	36.55	41.88	17 44
22, . .	16.91	24.68	15.82	23, . .	22.10	46.33	26.16
29, . .	21.36	22.85	16.95	30, . .	33.15	45.39	27.25
Feb. 5, . .	11.57	12.79	14.69	Aug. 6, . .	32.30	50.78	23.98
12, . .	14.24	14.62	11.30	13, . .	25.50	33.86	29.43
19, . .	11.57	21.96	14.69	20, . .	30.60	35.64	28 34
26, . .	21.36	21.11	16.95	27, . .	20.40	23.17	10.90
March 5, . .	16.91	20.11	21.47	Sept. 3, . .	23.83	31.22	21.74
12, . .	11.57	11.88	16.95	10, . .	22.10	30.29	19.62
19, . .	17 80	24.68	19.21	17, . .	15.30	33.86	11.99
26, . .	16.02	15.54	19.21	24, . .	17.85	32.08	15.26
April 2, . .	21.30	21.02	14.69	Oct. 1, . .	22.10	29.37	21.80
9, . .	19.58	18.28	21.47	8, . .	19.55	25.84	13.08
16, . .	22.25	23.76	16.89	15, . .	13.60	16.04	14.17
23, . .	25.81	20.11	14.69	22, . .	17.00	18.71	7.63
30, . .	27.59	18.71	28.25	29, . .	22.95	16.93	13.08
May 7, . .	19.58	25.59	15.82	Nov. 5, . .	15.30	20.49	16.35
14, . .	25.89	18.28	15.82	12, . .	17.00	16.93	11.99
21, . .	20.47	21.93	23.73	19, . .	21.25	18.71	18.53
28, . .	19.45	14.62	19.21	26, . .	23.80	23.17	25.07
June 4, . .	17.85	15.47	13.08	Dec. 3, . .	22.10	21.38	11.99
11, . .	13.60	16.93	14.17	10, . .	12.75	17 82	15.26
18, . .	13.60	16.04	18.08	17, . .	22.10	17.82	9.81
25, . .	17.30	24.06	9.18	24, . .	17.85	18.71	15.26
July 2, . .	23.80	23.17	17.44	31, . .	23.80	17.82	18.53

Population of Cambridge (estimated), ... 62,605
Total deaths, ... 1,326
Death-rate, 1887 (estimated), ... 21.18

Population of Fall River (estimated), ... 59,759
Total deaths, ... 1,603
Death-rate, 1887 (estimated), ... 26.82

Population of Lynn (estimated), ... 49,594
Total deaths, ... 887
Death-rate, 1887 (estimated), ... 17.88

Mortality-rates of Cities.

	Lawrence.	Springfield.	New Bedford.		Lawrence.	Springfield.	New Bedford.
Jan. 8, . .	18.76	11.04	23.40	July 9, . .	27.72	18 90	16.61
15, . .	14.74	9.45	10.92	16, . .	26.40	28.35	21.14
22, . .	30.36	13.80	17.16	23, . .	26.40	40.50	37.75
29, . .	18.76	18.90	15.60	30, . .	22.44	20.04	40.77
Feb. 5, . .	17.42	9.45	23.40	Aug. 6, . .	21.12	13.50	33.73
12, . .	20.10	28.98	15.60	13, . .	14.52	22.95	28.69
19, . .	20.10	11.04	12.48	20, . .	29.04	19.90	37.75
26, . .	28.14	10.80	25.67	27, . .	12.80	10.80	18.63
March 5, . .	10.72	15.18	31.20	Sept. 3, . .	10.56	14.88	31.79
12, . .	17.42	16.56	37.54	10, . .	21.12	17.55	28.69
19, . .	18.76	23.46	28.08	17, . .	11.88	13.50	24.16
26, . .	17.42	19.70	26.32	24, . .	11.88	29.70	27.18
April 2, . .	21.44	21.08	23.40	Oct. 1, . .	23.76	16.20	19.63
9, . .	20.10	20.70	10.92	8, . .	15.84	21.60	27.18
16, . .	30.92	13.50	24.96	15, . .	23.76	27 00	28.69
23, . .	21.44	19.32	24.96	22, . .	9.24	10.80	30.20
30, . .	12.06	13.50	15.60	29, . .	21.12	14.85	18.12
May 7, . .	13.40	11.15	23.40	Nov. 5, . .	10.56	10.80	25.67
14, . .	17.42	13.50	23.40	12, . .	34.38	22.95	15.10
21, . .	12.06	6.60	15.60	19, . .	18.48	17.55	15.10
28, . .	16.08	13.50	18.92	26, . .	17.16	14.85	12.08
June 4, . .	10.56	14.85	25.67	Dec. 3, . .	21.12	20.25	21.14
11, . .	18.48	17.55	13.59	10, . .	26.40	24.30	30.20
18, . .	17.16	10.80	21.14	17, . .	19.90	12.14	13.59
25, . .	15.84	16.20	22.65	24, . .	25.08	27.00	16.61
July 2, . .	22.44	25.65	12.08	31, . .	23.76	22.95	18.12

Population of Lawrence (estimated), ... 39,741
Total deaths, ... 974
Death-rate, 1887 (estimated), ... 24.51

Population of Springfield (estimated), ... 39,153
Total deaths, ... 750
Death-rate, 1887 (estimated), ... 19.15

Population of New Bedford (estimated), ... 34,361
Total deaths, ... 823
Death-rate, 1887 (estimated), ... 24.24

Mortality-rates of Cities.

	Somerville.	Salem.	Holyoke.		Somerville.	Salem.	Holyoke.
Jan. 8, . .	26.72	22.22	13.02	July 9, . .	40.08	22.08	19.25
15, . .	16.70	25.90	19.25	16, . .	30.06	29.44	33.25
22, . .	20.04	24.08	24.50	23, . .	23.38	23.92	17.50
29, . .	20.04	20.35	13.12	30, . .	20.04	34.96	33.25
Feb. 5, . .	11 69	18.50	7.00	Aug. 6, . .	28.39	34.96	19.25
12, . .	10.02	12.95	19.25	13, . .	26.72	33.12	22.75
19, . .	6.68	27.65	19.25	20, . .	13.32	23.92	19.25
26, . .	11.69	16.65	22.75	27, . .	23.38	20.40	12.25
March 5, . .	19.14	11.10	15.75	Sept. 3, . .	21.17	22.01	27.94
12, . .	12.18	31.45	17.50	10, . .	9.02	29.44	21.00
19, . .	12.18	24.05	13.02	17, . .	11.69	31.12	31.50
26, . .	26.10	25.90	10.60	24, . .	13.36	25.78	12.25
April 2, . .	22.62	22.20	18.60	Oct. 1, . .	21.71	20.24	19.25
9, . .	19.14	27.75	17.50	8, . .	23.38	16.56	12.25
16, . .	10.44	18.50	16.74	15, . .	15.03	36.80	8.75
23, . .	31.32	24.05	20.46	22, . .	16.70	23.92	12.25
30, . .	12.18	33.33	17.50	29, . .	23.38	20.24	28.00
May 7, . .	15.66	23.92	16.74	Nov. 5, . .	15.03	20.24	19.25
14, . .	12.18	27.75	14.00	12, . .	26.72	18.40	22.75
21, . .	22.72	29.60	18.60	19, . .	31.73	22.08	12 25
28, . .	19.14	31.45	18.60	26, . .	18.37	22.08	12.25
June 4, . .	11.69	16.56	14.00	Dec. 3, . .	16.70	27.60	29.75
11, . .	8.35	20.24	10.50	10, . .	16 70	16.56	14.00
18, . .	–	14.72	10.50	17, . .	28.39	18.40	7.00
25, . .	18.37	16.56	22.75	24, . .	25.05	29.60	17.50
July 2, . .	16.70	31.28	22.75	31, . .	20.14	22.08	19.25

Population of Somerville (estimated), ... 32,195
Total deaths, ... 621
Death rate, 1887 (estimated), ... 19.00

Population of Salem (estimated), ... 28,509
Total deaths, ... 739
Death-rate, 1887 (estimated), ... 25.92

Population of Holyoke (estimated), ... 29,889
Total deaths, ... 646
Death-rate, 1887 (estimated), ... 21.91

Mortality-rates of Cities.

	Chelsea.	Taunton.	Haverhill.		Chelsea.	Taunton.	Haverhill.
Jan. 8, . .	24.24	4.40	13.62	July 9, . .	14.07	12.96	27.24
15, . .	18.18	22 50	24.97	16, . .	22.11	12.96	38.59
22, . .	12.12	17.28	22.70	23, . .	26.13	10.80	9.08
29, . .	24.24	17.60	20.43	30, . .	30.15	38.64	29.51
Feb. 5, . .	12.12	15 12	11.35	Aug. 6, . .	34.17	21.60	31.78
12, . .	16.16	11.10	21.42	13, . .	20.10	30.24	31.78
19, . .	14.14	17.60	11.90	20, . .	18.09	23.76	20.43
26, . .	8 08	13.20	34.70	27, . .	8.04	8.64	18.16
March 5, . .	12.12	19.80	23.80	Sept. 3, . .	10.09	8.64	20.45
12, . .	20.20	22.00	14.28	10, . .	20.10	8.64	22.70
19, . .	20.20	13.33	11.90	17, . .	10.05	21.60	11.35
26, . .	22.22	9.80	19.04	24, . .	16.08	12.96	24.97
April 2, . .	24.24	15.50	26 18	Oct. 1, . .	20.10	17.28	15.89
9, . .	28.28	19.60	21.42	8, . .	14.07	15.12	15.89
16, . .	26.26	22.00	15.89	15, . .	22.11	15.12	13.62
23, . .	28.28	11.10	14.28	22, . .	26.13	17.28	15.89
30, . .	34.34	15.40	34.05	29, . .	16.08	12 96	24.97
May 7, . .	14.07	33.00	11.35	Nov. 5, . .	24.02	12.96	9.18
14, . .	16.16	17.60	14.48	12, . .	28.14	15.12	15 89
21, . .	18.18	6.60	14.28	19, . .	18.09	21.60	20.43
28, . .	10.10	8.80	11.90	26, . .	20.10	12.96	36.05
June 4, . .	14.07	19.44	15.89	Dec. 3, . .	18.09	23.76	15.89
11, . .	14.07	17.28	22.70	10, . .	24.12	15.12	22.70
18, . .	24.12	12.96	18.16	17, . .	14.07	10.80	24.97
25, . .	18.09	10.80	20.43	24, . .	18.09	19.44	15.89
July 2, . .	12.06	12.96	22.24	31, . .	32.16	15.11	29.51

Population of Chelsea (estimated), ... 26,938
Total deaths, ... 563
Death-rate, 1887 (estimated), ... 20.90

Population of Taunton (estimated), ... 24,422
Total deaths, ... 494
Death-rate, 1887 (estimated), ... 20.22

Population of Haverhill (estimated), ... 23,932
Total deaths, ... 469
Death-rate, 1887 (estimated), ... 19.59

Mortality-rates of Cities.

	Gloucester.	Brockton.	Newton.		Gloucester.	Brockton.	Newton.
Jan. 8, . .	16.73	15.00	13.05	July 9, . .	18.64	6.84	10.28
15, . .	25.63	20.52	10.52	16, . .	6.99	6.84	12.85
22, . .	21.51	22.80	2.63	23, . .	20.97	9.12	10.28
29, . .	16.73	25.00	7.89	30, . .	20.97	15.96	30.84
Feb. 5, . .	21.21	18.24	7.89	Aug. 6, . .	23.30	6.84	30.84
12, . .	16.73	18.24	21.04	13, . .	23.30	18.24	10.28
19, . .	11.95	25.00	5.26	20, . .	13.98	20.52	17.99
26, . .	14.34	25.00	13.15	27, . .	9.32	11.40	12.85
March 5, . .	21.51	4.56	18.41	Sept. 3, . .	6.97	15.97	12.85
12, . .	7.11	10.00	26.30	10, . .	20.97	22.80	28.27
19, . .	23.90	12.50	23.67	17, . .	9.32	13.68	12.85
26, . .	7.17	17.50	21.04	24, . .	18.64	18.24	17.99
April 2, . .	16.73	15.96	7.89	Oct. 1, . .	6.99	17.68	10.28
9, . .	2.39	11.40	13.15	8, . .	16.31	13.68	12.85
16, . .	16.73	20.00	13.15	15, . .	16.31	6.84	10 28
23, . .	14.34	11.40	13.15	22, . .	9.32	15.96	15.42
30, . .	19.12	12.50	10.52	29, . .	25.63	13.68	12.85
May 7, . .	19.51	15.00	31.36	Nov. 5, . .	6.99	2.28	10.28
14, . .	9.56	17.50	23.67	12, . .	11.65	15.96	20.56
21, . .	14.34	11.40	9.52	19, . .	18.64	11.40	5.14
28, . .	7.17	12.50	7.89	26, . .	23.30	11.40	17.99
June 4, . .	9.32	13.68	15.42	Dec. 3, . .	13.98	11.40	17.99
11, . .	9.32	18.24	17.99	10, . .	18.64	18.24	15.42
18, . .	18.64	9.12	25.70	17, . .	9.32	27.36	23.13
25, . .	6.99	2.28	7.71	24, . .	11.65	11.40	5.14
July 2, . .	13.98	11.40	15.42	31, . .	6.99	13.68	12.85

Population of Gloucester (estimated), ... 22,690
Total deaths,* 442
Death-rate, 1887 (estimated), ... 19.48

Population of Brockton (estimated), ... 24,795
Total deaths, ... 357
Death-rate, 1887 (estimated), ... 14.39

Population of Newton (estimated), ... 20,656
Total deaths, ... 322
Death-rate, 1887 (estimated), ... 15.59

* 106 lost at sea included in the above.

Mortality-rates of Cities.

	Malden.	Fitchburg.	Waltham.		Malden.	Fitchburg.	Waltham.
Jan. 8, . .	15.85	19.74	10.68	July 9, . .	30.11	19.74	10.20
15, . .	17.80	16.90	7.12	16, . .	9.03	32.90	10.20
22, . .	34.87	13.52	17.00	23, . .	18.06	19.74	20.40
29, . .	15.85	20.28	28.48	30, . .	27.09	29.61	20.40
Feb. 5, . .	3.17	16.90	32.04	Aug. 6, . .	6.02	52.64	13.60
12, . .	22.19	14.16	24.92	13, . .	15.05	16.45	17.00
19, . .	12.68	6.76	7.12	20, . .	18.06	19.74	20.40
26, . .	6.24	27.04	21.36	27, . .	6.02	42.77	17.00
March 5, . .	9.51	20.28	21.36	Sept. 3, . .	15.04	19.77	13.58
12, . .	19.02	16.45	24.92	10, . .	18.06	16.45	17.00
19, . .	31.70	33.80	14.24	17, . .	15.05	23.03	30.60
26, . .	12.04	16.90	21.36	24, . .	9.03	19.74	13.60
April 2, . .	6.34	20.28	32.04	Oct. 1, . .	3.01	29.61	10.20
9, . .	15.85	27.04	7.12	8, . .	12.04	16.45	27.20
16, . .	15.85	16.90	7.12	15, . .	12.04	32.90	20.40
23, . .	22.19	23.03	24.48	22, . .	18.06	9.87	23.80
30, . .	28.53	9.87	14.24	29, . .	3.01	6.58	13.60
May 7, . .	25.36	23.66	35.60	Nov. 5, . .	24.08	13.16	3.40
14, . .	12.68	10.14	3.56	12, . .	15.05	23.03	13.60
21, . .	12 68	13.52	21.36	19, . .	21.07	23.03	23.80
28, . .	15.85	13.52	17.00	26, . .	27.09	26.32	20.40
Juue 4, . .	12.68	13.16	10 20	Dec. 3, . .	27.09	13.16	20.49
11, . .	24.08	13.16	20.40	10, . .	15.05	23.03	13.60
18, . .	6.24	6.58	17.00	17, . .	21.07	23.03	30.60
25, . .	12.68	19.74	13.60	24, . .	15.05	26.14	20.40
July 2, . .	12.04	16.45	6.80	31, . .	24.08	39.48	6.80

Population of Malden (estimated), ... 18,090
Total deaths, ... 321
Death-rate, 1887 (estimated), ... 17.74

Population of Fitchburg (estimated), ... 16,147
Total deaths, ... 339
Death-rate, 1887 (estimated), ... 20.98

Population of Waltham (estimated), ... 15,971
Total deaths, ... 288
Death-rate, 1887 (estimated), ... 18.03

Mortality-rates of Cities.

	Newburyport.	Northampton.		Newburyport.	Northampton.
Jan. 8, . . .	3.78	7.92	July 9, . . .	22.68	19.80
15, . . .	22.80	7.94	16, . . .	30.24	19.80
22, . . .	15.20	24.18	23, . . .	26.46	7.94
29, . . .	22.40	3.96	30, . . .	34.02	19.80
Feb. 5, . . .	37.80	11.88	Aug. 6, . . .	26.46	35.84
12, . . .	19.00	24.18	13, . . .	22.68	27.79
19, . . .	15.20	19.80	20, . . .	15.12	19.80
26, . . .	15.20	20.15	27, . . .	15.12	39.60
March 5, . . .	15.20	39.60	Sept. 3, . . .	26.46	23.82
12, . . .	7.56	15.84	10, . . .	45.36	11.91
19, . . .	38.00	27.79	17, . . .	11.34	11.91
26, . . .	11.40	20.15	24, . . .	22.68	23.92
April 2, . . .	38.00	24.18	Oct. 1, . . .	15.12	7.94
9, . . .	30.40	19.80	8, . . .	26.46	3.96
16, . . .	18.90	23.82	15, . . .	11.34	7.94
23, . . .	12.50	27.79	22, . . .	30.24	3.96
30, . . .	27.30	12.09	29, . . .	22.68	7.94
May 7, . . .	22.60	3.96	Nov. 5, . . .	22.68	3.96
14, . . .	18.90	27.79	12, . . .	30.24	19.80
21, . . .	41.80	12.09	19, . . .	26.46	19.80
28, . . .	19.00	7.94	26, . . .	22.68	3.96
June 4, . . .	15.84	3.97	Dec. 3, . . .	22.68	3.96
11, . . .	15.12	7.94	10, . . .	49.14	27.79
18, . . .	26.46	3.96	17, . . .	22.68	31.76
25, . . .	26.46	23.76	24, . . .	18.90	11.91
July 2, . . .	30.24	15.88	31, . . .	15.12	–

Population of Newburyport (estimated), ...	13,796
Total deaths, ...	381
Death-rate, 1887 (estimated), ...	27.62
Population of Northampton (estimated), ...	13,322
Total deaths, ...	252
Death-rate, 1887 (estimated), ...	18.99

THE VENTILATION OF SCHOOL-ROOMS HEATED BY STOVES.

By J. G. PINKHAM, A.M., M.D., LYNN.

THE VENTILATION OF SCHOOL-ROOMS HEATED BY STOVES.

By information derived from replies to a circular letter of inquiry issued by the State Board of Health, and addressed to the school authorities of all the cities and towns of the State, it has been ascertained that there are in the State about 3,860 school-rooms heated by stoves, and that these rooms accommodate 131,200 pupils.

The subject proposed for discussion in this paper may be seen by the above figures to be one that concerns directly the welfare of more than one-third of the school population of the State. It is a subject which has received less attention from writers upon school hygiene than its importance, as thus shown, would seem to demand.

A majority of the school-rooms under consideration are in country districts, or in villages, and in buildings that contain but one or two rooms. That they should be heated by some form of stove seems almost a matter of necessity. Open fire-places and grates do not furnish heat enough for very cold weather. With so humble a class of buildings, heating by steam or by hot water is out of the question. In many cases there is no cellar or basement; hence the hot-air furnace could not be employed without a large preliminary outlay. Moreover, as ordinarily used, the furnace is an expensive and unsatisfactory method of heating.

Taking it for granted, therefore, that stoves will continue to be used in these rooms, the question of ventilation must be considered in connection with this form of heating.

In the following pages it is proposed, first, to describe briefly the prevailing methods of ventilation in such rooms, and point out, in a general way, their defects; secondly, to

show that by means of jacketed stoves it is possible to heat school-rooms satisfactorily, and at the same time to supply a sufficient amount of pure air without disagreeable or dangerous draughts.

I. Prevailing Methods of Ventilation.

The reports of our correspondents throughout the State indicate that, with very few exceptions, the school-rooms that are heated by stoves are supplied with means for only the most simple form of natural ventilation. That is, a communication is made with the outside air, and such an exchange of that with the air of the room is allowed to take place as is brought about naturally by the difference in temperature or the force of the winds.

In nine-tenths of the rooms reliance is placed mainly upon doors and windows as means of ventilation. About one-fourth of them have some special appliances attached to the windows, either at the top or bottom, — the object being to give an upward direction to the inflowing current of air, or to so divide and diminish it that the draught may be less sensibly felt. Among the devices used in connection with window ventilation are the following: —

1. A narrow strip of board placed under the lower sash, the air being allowed to enter at the middle of the window between the sashes.

2. A strip of board nailed to the casing across the lower part of the window. When the lower sash is slightly raised air enters between it and the board, and also between the sashes.

3. A screen of fine wire netting fastened to the window-casing on the outside.

4. A box, open on the upper and outer sides, fastened to the window-casing at the top, in such a way that when the upper sash is lowered a current of air enters and is deflected upward toward the ceiling. A strip of board fastened obliquely in the same situation, or hinged and opening inwards, is sometimes made to effect the same result as the box

5. Revolving ventilators, occupying the space of the window-pane.

6. Double windows with holes through the bottom bar of the frame of the outside window. When the top sash of the inside window is lowered fresh air is admitted.

7. Ducts passing through a board placed under the lower sash, and turning upward.

A few of the rooms are furnished with other means of ventilation, such as the following: —

1. Transoms over doors and windows.

2. Openings in the side walls of the buildings, mostly near the top of the room.

3. Openings in floors.

4. Openings in ceilings. These either communicate with the outer air by means of a duct which extends up through the roof, or they open directly into the attic. In the latter case the attic becomes a foul-air chamber from which access to the outer air is had through the window, by an opening in the roof, or not at all.

5. Special flues in chimneys, or openings into smoke flues.

All these methods of ventilating, or more strictly speaking varieties of one method, are open to the objections that they cannot, under ordinary circumstances, supply air enough, and that they make no provision for warming the incoming air in cold weather. That they cannot supply air enough is true at all times of the year except when the weather is so warm as to allow the free opening of doors and windows.

A reasonable estimate of the amount of fresh air required by the pupils of an ungraded school would be two thousand cubic feet each per hour. For a school-room containing ten thousand cubic feet of air-space, and accommodating forty-five pupils, this would mean that eighty thousand cubic feet of fresh air must be supplied each hour, or that the air of the room must be changed completely once in every seven and one-half minutes. The impossibility of effecting such a result in cold weather, and of keeping the room warm at the same time, with the means of heating and ventilating in common use, must be apparent to any one; and without regard to the temperature of the room, it would be difficult to effect it except by means of widely opened windows or doors, and a strong breeze blowing directly in.

The openings between window sashes, so much depended on for ventilation, are very small; probably they do not average for the different windows more than twenty square inches.* Six of them would amount to only one hundred and twenty square inches, or five-sixths of a square foot. If, in the case supposed above, we should allow six windows with strips of board under the lower sashes to act as inlets, provision being made for the escape of foul air by an opening in or near the top of the room, we should have as favorable conditions for good ventilation as one would be likely to meet with in school-rooms heated by stoves. If air should enter at the rate of two hundred linear feet per minute, — a liberal estimate, — the amount supplied would be ten thousand cubic feet per hour, just one-eighth of what would be needed. If no escape for foul air were provided, as is often the case, some of the windows would have to act as inlets and others as outlets, — in which case the movement would be slower, and the air supply much less.

The above is a fair picture of ordinary school-room ventilation at its best. Add to the amount given the air which finds entrance through the cracks of a poorly constructed building, and that which is admitted by opening doors and windows during recess, or periods of exercise, and we still do not have enough to prevent the air of the room from becoming decidedly foul, and remaining so during a considerable portion of the time when the school is in session. The truth of this statement will be clearly shown later by means of observations made upon some of the school buildings in the city of Lynn.

But even this limited air supply involves a certain amount of danger in cold weather from draughts and unequal heating. The evil is not imaginary. It is extremely common for children who are compelled to sit near open windows in school-rooms to complain of the draught, and to take cold from this cause. It is quite as common for those who sit near the stove to suffer from an excess of heat. On very cold days — not a few in this latitude — it is necessary to

* The most narrow part of these openings should be measured. This is usually the space between the lower bar of the upper sash and the lower window-pane. For many rooms the estimate given is doubtless too high.

cut off entirely, or as far as possible, the fresh air supply, in order to keep the room comfortably warm. At such times the foulness of the air becomes painfully noticeable to those who visit the school. Nearly all of those who made reply to the circular letter before referred to admit that, as a rule, the school-rooms in which stoves are used are unequally heated and badly ventilated.

A few extracts from the replies of our correspondents are given, to show the opinions entertained on this subject by those who have charge of the schools: —

1. All our schoolhouses are heated by stoves. Very little attention is given to ventilation. The houses are old-fashioned, country schoolhouses, one story high, consisting of one room, nearly square, with a hall and wood-room at one end. The rooms are liable to become uncomfortably warm or cold in a short time.

2. In all the rooms in which dependence is placed upon window ventilation, the forgetfulness or neglect of teachers engenders great and frequent risks to health by cold currents or draughts upon children.

3. Windows opened at top. Results unsatisfactory. If hot air goes out, cold air comes in. It strikes the heads near by, and induces catarrhal troubles. M. D.

4. While we instruct the teachers to keep one or more windows down at the top all the time, and to ventilate thoroughly at recess, still, from neglect or fear of exposure, we often find the air foul and unfit for breathing. I should be glad to find some means for more perfect ventilation.

5. The ventilation of all our rooms which are heated by stoves s very unsatisfactory. We are forced to depend on the windows ifor a supply of fresh air, and can only keep the atmosphere of the rooms wholesome by frequently throwing these wide open (during recess or the time devoted to gymnastics) and creating a strong cross current.

6. The ventilation of our school-rooms is very unsatisfactory and imperfect.

7. Very little attention, if any, given to the principles of ventilation.

8. In none of our schools is there any method of ventilation, except that of opening doors or windows. Lack of ventilation and untidy water-closets, or privies really, are among the most prominent defects in our schoolhouses in this town. I am glad that the matter is being investigated by the State.

9. Our high-school room was built with ventilation in the floor and in the chimney, but the committee finding the floor ventilation a nuisance discontinued it. It being an upper room, the ventilator admitted both cold and foul air. The chimney ventilation amounted to but little. We now intend to place a strip of board at the bottom of the window, and, raising the lower sash upon it, allow the air to enter where the two sashes come together.

II. The Use of Jacketed Stoves.

It may be taken for granted that it is impossible to supply school-rooms with the large amount of fresh air required for proper ventilation, and at the same time keep up the temperature, unless provision is made for warming the air before or during its introduction. To accomplish this economically with the class of rooms under consideration, the jacketed stove, or some form of heater arranged on the same principle, seems to be the only available device.

The plan is not new. It has been in use for many years in one form or another; but the writer is not aware that any account has been published hitherto of a systematic attempt to secure by this method air enough to meet the requirements of a perfect system of ventilation. In the replies of our correspondents mention is made of the use of jacketed stoves in forty-two rooms in different cities and towns throughout the State. Six of these rooms are in Lynn. A detailed account of the plan pursued in them and of the results attained is to be given in this paper. In regard to the other rooms the information furnished is so meagre that it is impossible to judge whether the system has been successful in them or not.

Experience in Lynn. — The work about to be described was performed under the direction of the committee on sanitation of the Lynn school board.

The air analyses were made by Prof. Wm. B. Hills, of the Harvard Medical School.

The diagrams and charts were prepared by Mr. T. P. Perkins, civil engineer, of Lynn. The latter gentleman also collected the air samples and made the observations recorded in the tables accompanying the charts.

Three primary-school buildings, each containing two rooms, have been heated and ventilated in the way mentioned. The arrangement at the Red Rock Street schoolhouse has given the best results, and is regarded as the most worthy of imitation. For this reason it will receive a somewhat more particular description than that at the other buildings.

Red Rock Street Schoolhouse.

This is a brick building of good construction and in a healthy locality. The ventilating apparatus was put into it during the summer of 1886, and the description which follows is from the report of the committee on sanitation for that year: —

There are in each room two large stoves (Barstow's "Puritan," No. 18), one on each side of the room, near the front. Each stove is encased in a galvanized iron jacket about six and one-half feet high, with a spreading base. Air is admitted to the space between the stove and its jacket by an air-box running through the side wall, the opening for each stove having a sectional area of four and one-half square feet, being large enough for the whole air supply of the room. In cool weather one stove in each room is used; in cold weather both stoves.

There are two extraction flues, built in one stack, at the rear of the building, one with a sectional area of 5.2 square feet for the upper room, and one with a sectional area of 4.1 square feet for the lower room. They are of brick, and in an inner corner of each is a fire-clay smoke pipe connecting with the stove pipes. These smoke pipes end at the level of the chimney top, and the whole is covered with an iron cap, like an Emerson ventilator, but rectangular. For heating the flues one of D. W. Cushing's "Ring Cylinder" stoves is set into the *with*, or partition between the flues, projecting into each. The flues are enlarged opposite the stove to compensate for the obstruction of its bulk. As the cellar does not extend under the rear of the building the flues end at the

floor level of the lower room. The openings from the rooms into the extraction flues are made at this level, from the lower room directly through the wall, and from the upper room by means of a thirty-inch tin pipe, running down beside the stack, from the upper floor. The flue-heating stove is set about three feet above the lower floor, and access to it is had through an iron door opening into the school-room. Most of the air withdrawn from the rooms goes through large openings close to the stack; the remainder (15 or 20 per cent.) is drawn through ducts under the back platform, and thence into the extraction flues. The total area of outlet openings from each room is about equal to the sectional area of its extraction flue. All outlet openings are covered with wire netting of about one inch mesh. Inlets on outside of building are protected by boxing and fine netting.

The illustrations which follow will make this description plain. All dimensions are given in the floor-plan and sections. The capacity of the lower room is 10,700 cubic feet, that of the upper, 12,040 cubic feet, allowance being made for chimney, platforms, stoves and jackets, but none for furniture or persons. The air space per scholar, using the average attendance during the winter term of 1886 as the basis of calculation, is for the lower room one hundred and ninety-four cubic feet, for the upper room two hundred and forty cubic feet. The actual air space enjoyed by each pupil in any school varies, of course, from time to time with the number in attendance. The average age of the pupils in the lower room is seven years, nine months; in the upper room nine years, six months. The results at this schoolhouse have been most excellent, as shown by charts A and B, and the accompanying tables. There was no difficulty in managing the apparatus after its working was fully understood.

Visitors to the school note the seeming purity of the air, and the teachers bear similar testimony.

Measurements of the outflowing air have been made at various times. These show an average for the lower room of 108,510 cubic feet per hour, or about 2,100 cubic feet to each pupil; for the upper room 84,664 cubic feet, or about 1,900 cubic feet to each pupil. In making these estimates the cubic contents of the rooms were added to the

outflow, and the average attendance of the pupils employed as a factor.

It is probable that in mild weather these figures would be somewhat reduced. They might be considerably reduced, and still leave quite a liberal supply for pupils of the ages specified if the commonly received views as to the amount required are correct. It is intended that the fire shall be kept burning in the flue-heating stove at all times, except in warm weather. In this way the air supply may be kept up when the jacketed stoves are not in use.

The air analyses have very uniformly shown good results.

Chase Avenue Schoolhouse.

The arrangement at this schoolhouse differs from that at the Red Rock Street schoolhouse in the following particulars only: —

1. The chimney flues extend into the cellar and the foul air from both rooms is carried down by large tin ducts and discharged into them at the bottom. The flue-heating stove is in the cellar. The net area of each flue on cross section is 3.7 square feet.

2. The extraction flues are of the same size throughout, and the smoke pipes pass up through the centre.

3. The foul-air outlets, twelve in each room, are provided with registers, and arranged along the sides and back of the room.

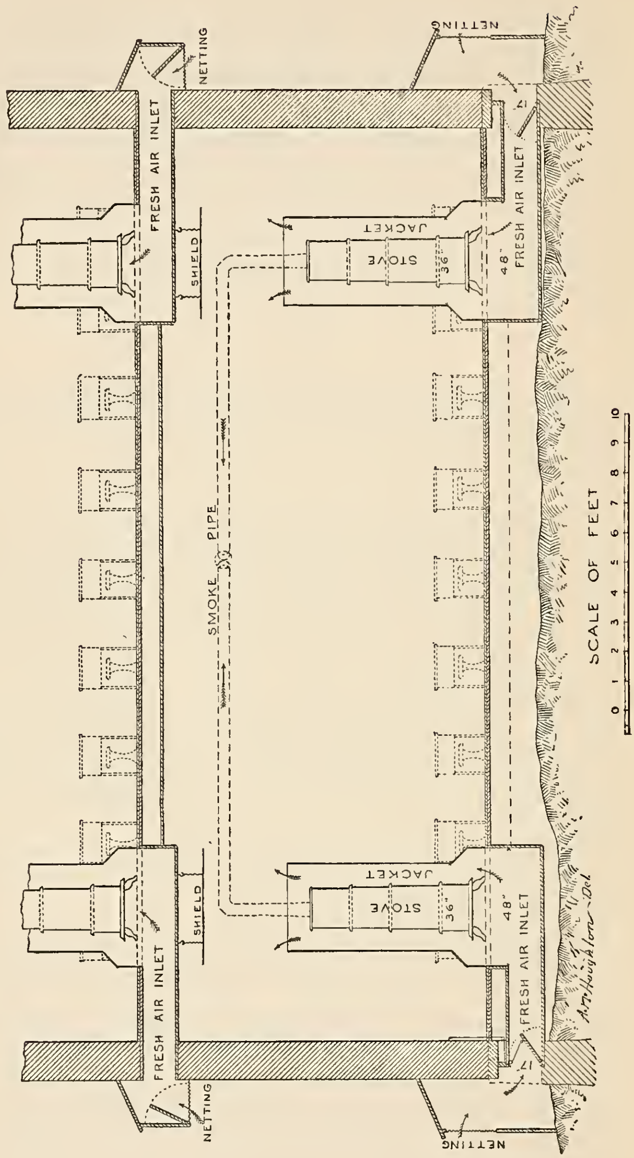
4. The chimney is capped with a louver, through which the smoke pipes extend.

5. The fresh-air inlet in the lower room has an area on cross section of 4.4 square feet; that of the upper room an area of 2.47 square feet. The structure of the building made it difficult to put in a larger inlet duct in the upper room.

These details are given because they furnish an explanation of the fact which will soon appear, viz.: that the amount of air supplied at this building is considerably less than at the Red Rock Street schoolhouse.

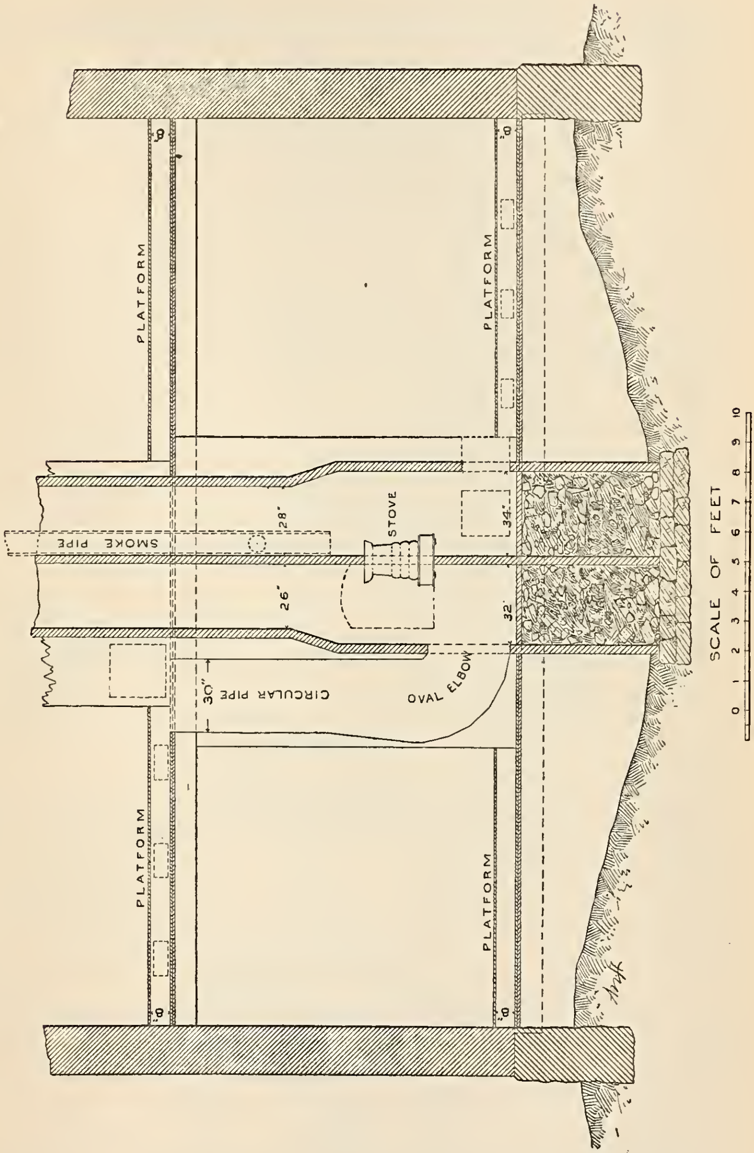
RED ROCK STREET SCHOOL HOUSE

SECTION THROUGH HEATING STOVES AND FRESH AIR INLETS



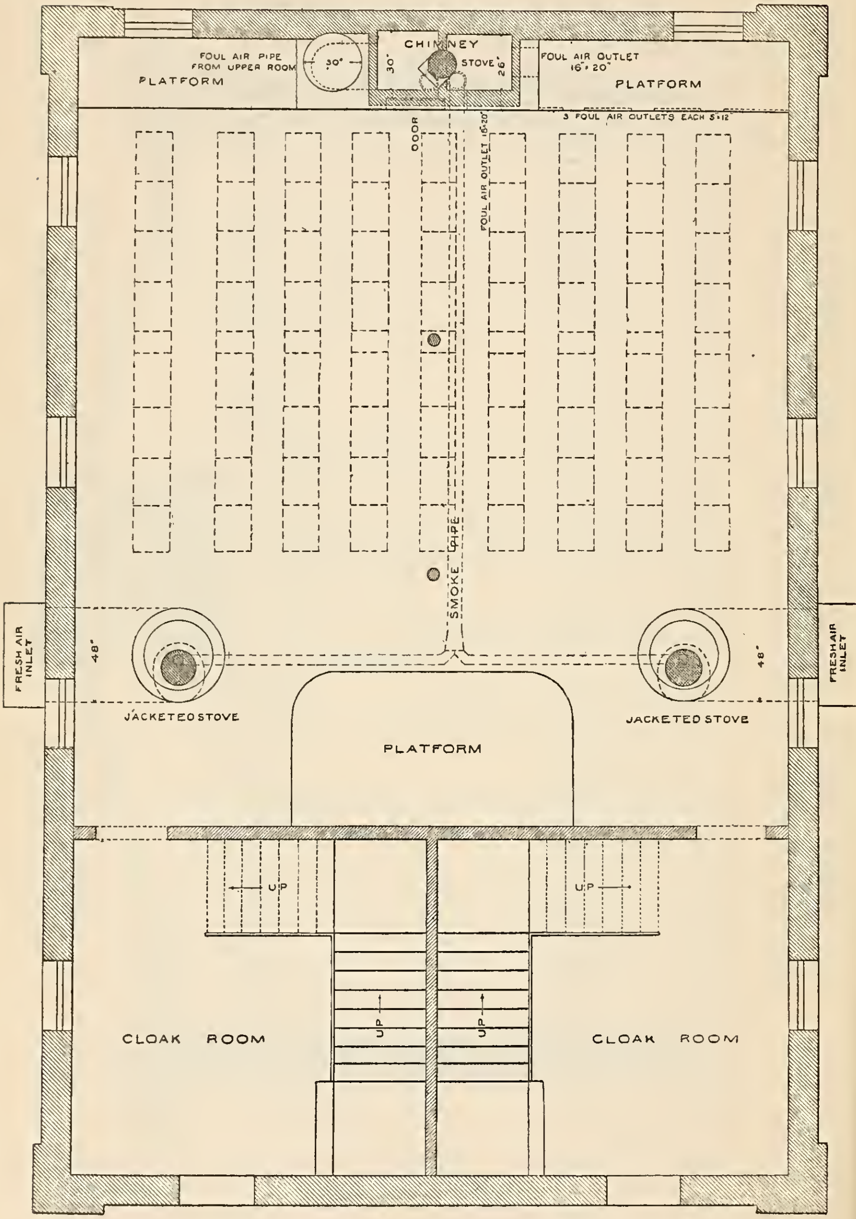
RED ROCK STREET SCHOOL HOUSE

SECTION THROUGH CHIMNEY ON LINE PARALLEL TO REAR WALL



RED ROCK STREET SCHOOL HOUSE LOWER ROOM

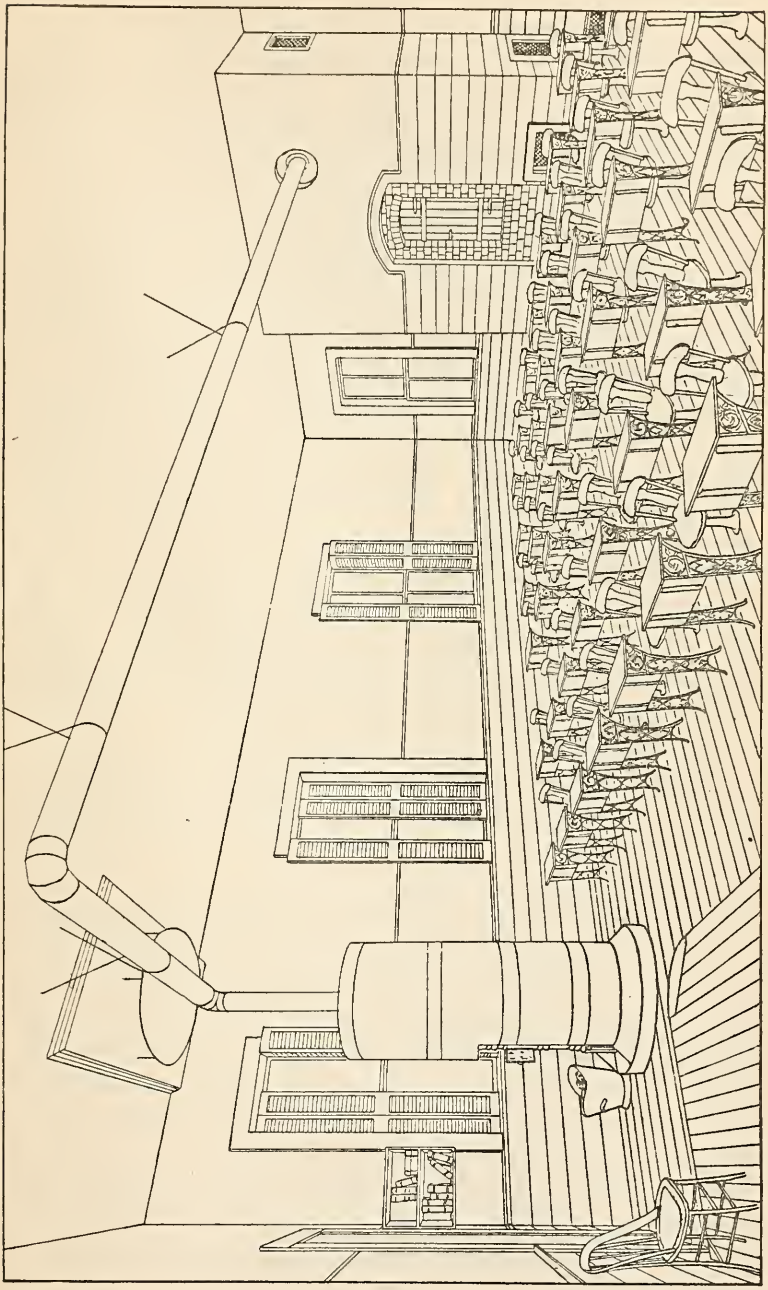
PLAN



FRONT

SCALE OF FEET

0 1 2 3 4 5 6 7 8 9 10



RED ROCK STREET SCHOOL, LOWER ROOM, SHOWING ONE STOVE.

The air-meter tests have been difficult to make on account of the numerous outlets, and the somewhat indefinite amount of obstruction caused by the registers. The figures given are probably an under-estimate. Early in the year 1886 measurements with the air-meter were made in the lower room, and showed an outflow of 45,000 cubic feet per hour. Two samples of air taken from this room at the same time were analyzed by Professor Hills with the following result: — No. 1. taken in front of the teacher's desk gave 7.93 volumes of carbonic acid in ten thousand volumes of air, and No. 2. taken in the back part of the room among the scholars, and at the breathing line, gave 9.68 volumes.

The results of other examinations are shown in chart C and the tables. The amount of carbonic acid in the air of the lower room appears to be kept uniformly below ten. That of the upper room rises above ten just before recess and at the close of school.

Before the improvements were made this building was notoriously the worst ventilated schoolhouse in the city. A sample of air taken from one of the rooms before recess showed nearly thirty parts of carbonic acid in ten thousand volumes of air. The close, bad odor of the rooms was observed by all who had occasion to visit them.

The building was worse than others in this particular, because it was better built, and hence more nearly air-tight. It had no available means of ventilation except the doors and windows.

To enlarge the fresh-air inlet in the upper room, giving it an area on cross section of not less than four square feet; to remove the registers in both rooms, substituting coarse wire netting, or, still better, to close them altogether, and make large openings directly into the tin ducts which lead to the extraction flues, would probably place this building nearly on a level with the one on Red Rock Street in regard to the amount of air supplied.

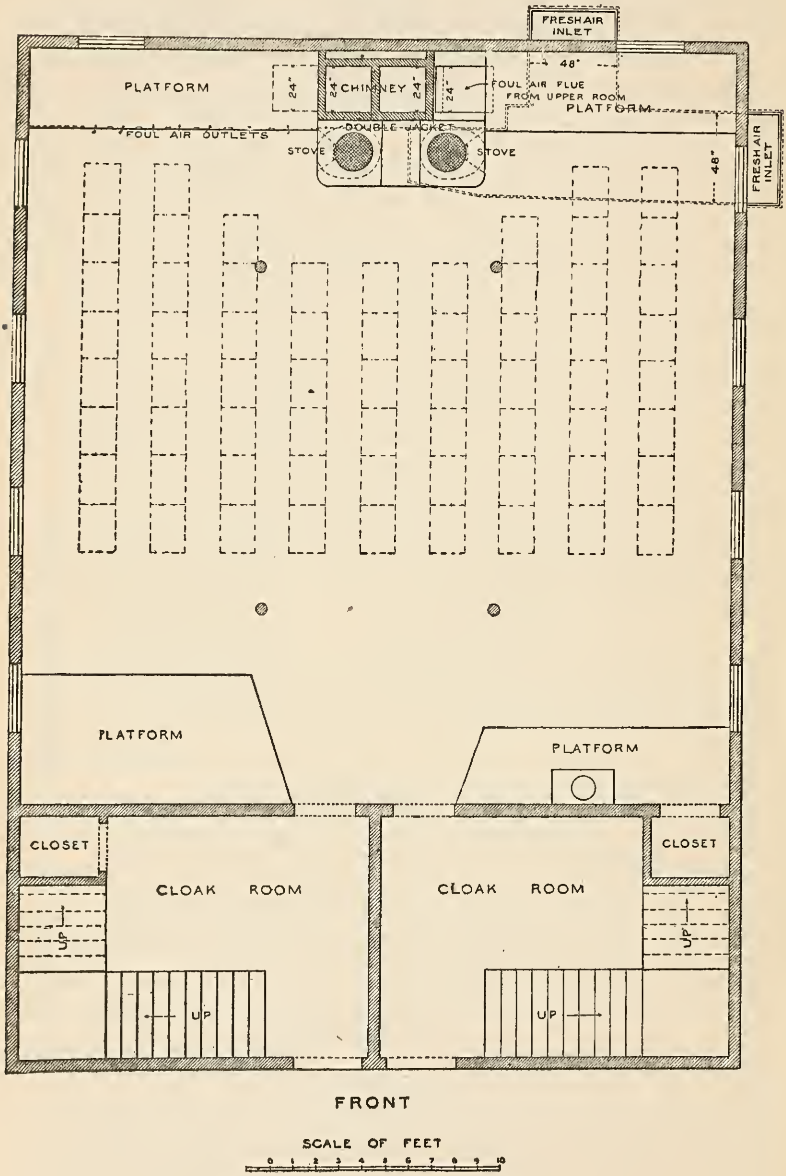
As a matter of minor importance it may be mentioned that the louver on the top of the chimney is thought to be less effective for its purpose than the arrangement in use at the other buildings.

Baltimore Street Schoolhouse.

This is an old wooden building, with thin walls, and of rather loose construction. The rooms are so arranged as to make it inconvenient to place the stoves in the front part. They were, therefore, placed in the back part, as shown in the illustrations. Those in the lower room are enclosed in a double jacket, and placed directly in front of the chimney. The fresh air is admitted to a chamber underneath the platform, and from thence is conducted to the jacket, traversing both stoves before its escape into the room. In the upper room the stoves are surrounded by cylindrical jackets and placed one on each side of the chimney. The smoke pipes open directly into the flues. The foul air from both rooms is carried down to the bottom of the chimney by tin ducts, as at the Chase Avenue schoolhouse. On account of the character of the building it was not thought best to attempt to supply so much air as at the Red Rock Street schoolhouse. Hence the extraction flues and inlets were made somewhat smaller. The diagram shows a section through the chimney, the stoves in the upper room, the foul-air ducts, etc. The view is from the front, and the stoves in the lower room are shown in dotted lines. The arrangement in this building has an advantage over the others in that the apparatus occupies but little space, and is out of the way. It was put in during the summer of 1887, and has hardly been in operation long enough to determine fully its merits or defects. The observations thus far made, as exhibited in charts D and E and the tables, prove that the air of the rooms is generally pure. But they show at the same time that there is occasionally a failure of the respired air to diffuse itself rapidly or to pass away from the breathing zone; a fact which may, perhaps, be accounted for by the entrance of cold air by other channels than those which lead to the stove jackets. Such an event would not only keep the floor cold, but would cause the air in the middle of the room to remain more or less stagnant at times, — in fact, to give us the results shown by certain of the air analyses. That this is true, a brief consideration of the physical laws which control the movements of air under such circumstances will make apparent.

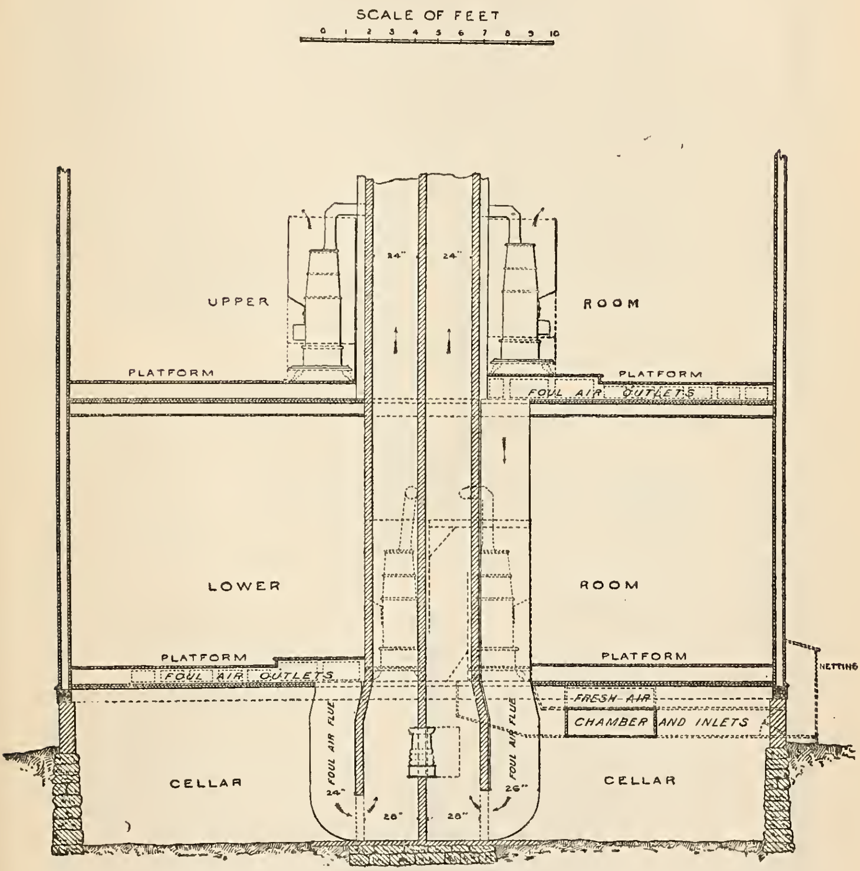
BALTIMORE STREET SCHOOL HOUSE LOWER ROOM

PLAN



BALTIMORE STREET SCHOOL HOUSE

SECTION THROUGH CHIMNEY ON LINE PARALLEL TO REAR WALL



Samples of air taken at different altitudes from near the middle of the lower room, December 31, gave the following results: —

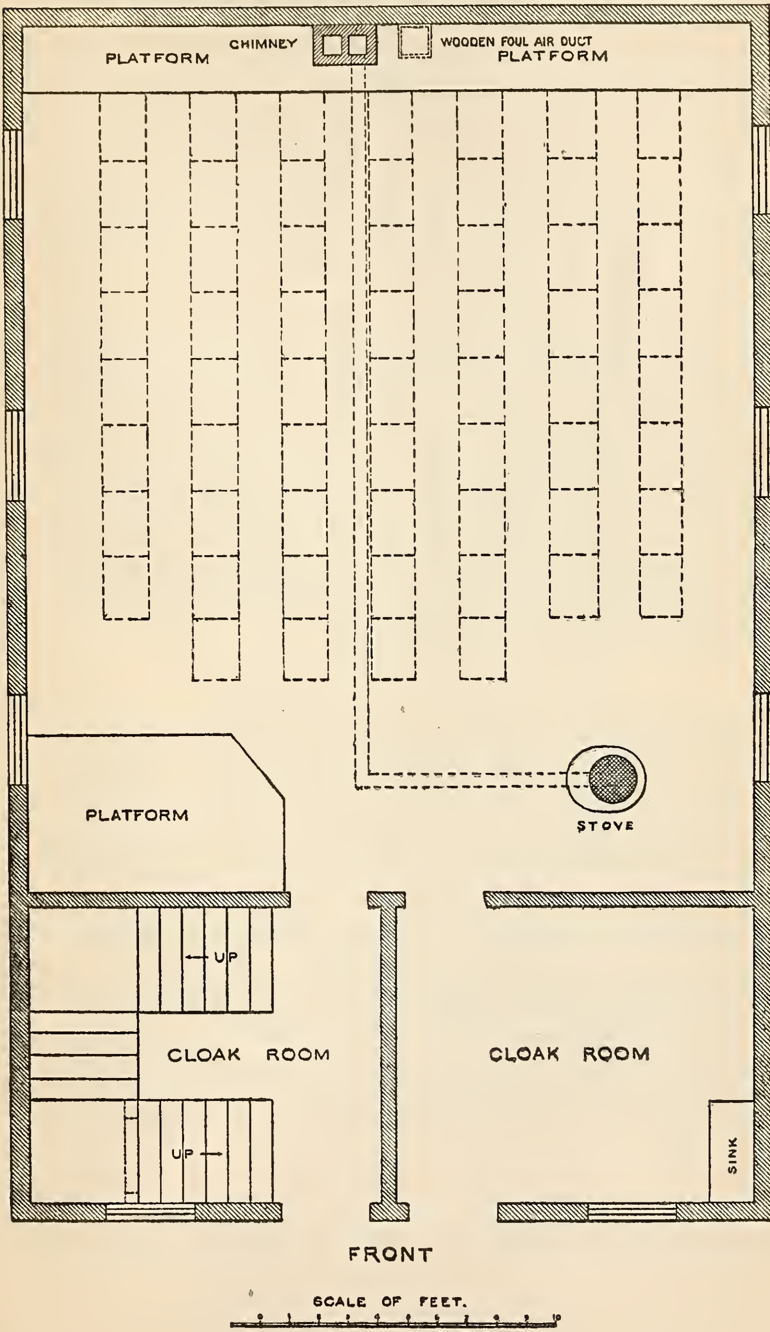
Just before recess, at floor, 8.29 parts of carbonic acid to ten thousand volumes of air; at the breathing line of pupils, 13.66 parts; at the ceiling, 6.16 parts. Near the close of the session, at floor, 4.16 parts; at the breathing line, 6.51 parts; at the ceiling, 7.64 parts. The day was an extremely cold one, and as the fires had not received proper attention in the morning the room did not get fairly warmed until after ten o'clock. The upper ventilator in the chimney had also been left open during the early part of the session, allowing the pure, warm air to escape in the most direct way possible. When the room is well warmed, as it was on February 23, the date of the observations shown in the chart, the air is thoroughly diffused. This appears to be proved by the constant purity of the air at the breathing line, a fact which the analyses of that date show. Further comments upon the difficulties experienced at this schoolhouse will be made under the head of "Temperature."

In order to show more clearly the contrast between these schoolhouses and those heated and ventilated after the old method, two of the latter will be described, and the results of observations made in connection with them given. As a matter of convenience they will be referred to as the unventilated schoolhouses.

Jackson Street Schoolhouse.

This is an old, two-story wooden building, something like the one on Baltimore Street, but with a slightly different arrangement of the rooms, as shown by the accompanying plan. For ventilation we have in the lower room a wooden duct, 12 × 12 inches, projecting down 2 feet 9 inches from the ceiling. It is placed about ten inches from the chimney, and opens into the attic at the floor level. There is, also, an opening about 8 × 10 inches into the chimney-flue at the floor, closed by an iron door, which is often left open, but not always, for sometimes it spoils the draught of the stove and

JACKSON STREET SCHOOL HOUSE LOWER ROOM



lets gas into the room. The windows, furnished with boards placed under the lower sashes, are used as inlets.

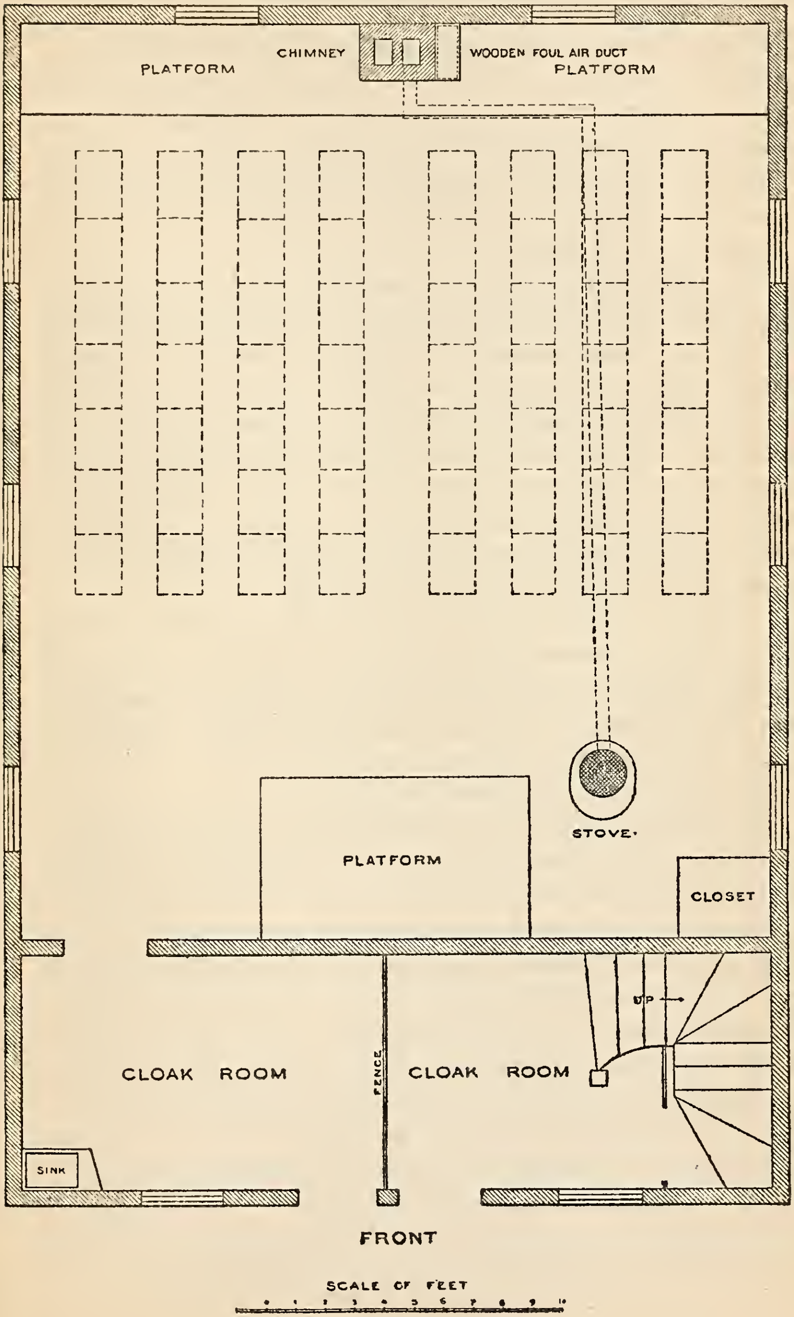
In the upper room there is a wooden duct 9 × 12 inches, running up close alongside the chimney, and discharging into the attic at the floor level. There is, also, a hole in the ceiling about 15 inches square, letting air into the attic. The attic has a wooden duct 14 × 16 inches, running through the ridge of the roof, and projecting down into the attic about two feet. This duct has a board across the top, and four small openings at the side.

The window boards are used as in the lower room. Teachers have general directions, as in all the schools, to ventilate at recess, and in other ways to keep the air of the rooms as pure as possible without endangering the health of the pupils by exposing them to cold draughts, or to an unreasonably low temperature. A study of charts F and G with the accompanying tables will show how extremely unsatisfactory the ventilation of this building is. It is not too much to say that at the close of school and just before recess the air becomes horribly foul.

George Street Schoolhouse.

This building is made on the same general plan as the above. Each room has a separate wooden duct running up by the side of the chimney, the two combining in the attic, turning at right angles three times, and going out through the roof about six feet from the chimney. The duct from the lower room is 7 × 20 inches, that from the upper room 6½ × 21 inches. Into each duct there are two openings, one at the top and the other at the bottom of the room, each 10 × 14 inches, with hinged doors. The windows are supplied with boards as at the Jackson Street schoolhouse. Charts H and I, with the tables, set forth the results of observations and emphasize the remarks in the preceding section.

GEORGE STREET SCHOOL HOUSE LOWER ROOM



General Observations.

The Charts. — The charts are modelled after those of Professor Rietschel, of Berlin.* They show the number of pupils, amount of carbonic acid, relative humidity, temperature in degrees Fahrenheit, and time. On the opposite page the observations which form the basis of the charts are given in tabular form, together with notes that fully set forth all the conditions.

The Test of Purity. — In obtaining the samples of school-room air for analysis the instructions of Professor Hills were followed. Large bottles with tightly fitting rubber stoppers were used. The bottles were filled by means of a pair of bellows, with a long piece of rubber tubing attached to the nozzle. Except as otherwise specified the samples were all taken in the middle of the room, and at the breathing line of the pupils. The bottles were sealed and carried at once to the laboratory of the Harvard Medical School, where the determinations were made.

It needs but a glance at the charts to show the wide differences between the ventilated and the unventilated school-rooms. The results here given are in entire accordance with those of other observations previously made under the direction of the school committee of Lynn, and with the evidence derived from the senses.

It may be stated by way of explanation to those who have, perhaps, given less study to the subject than the writer, that the standard of purity set up by the highest authorities (Dr. Parkes, Angus Smith, DeChaumont and others) is that of six, or, at the most, eight parts of carbonic acid in 10,000 volumes, of air. When the amount is ten parts or more the impurity becomes manifest to the senses. Some writers contend that in school-rooms it is not practicable, usually, to keep the amount of carbonic acid much below ten, on account of the large number present and the limited air space. Ten should certainly be regarded as the extreme upper limit.

We may say, then, that when the black line, representing the amount of carbonic acid in the charts, keeps below six

* Lüftung und Heizung von Schulen. Berlin, 1886.

the ventilation is *perfect;* when it rises above six, but does not go above eight, it is *good;* when it rises above eight, but does not go above ten, it is *fair;* when it rises above ten, it is bad in proportion to the amount of carbonic acid shown to be present.

Let it be observed that in the four charts based on observations made in the unventilated rooms the carbonic acid line very speedily gets above ten, even when it starts from a point near the line of atmospheric purity, as in chart I.

In the case of chart H the tables and notes will show that there was an outflow from the ventilators of nearly 13,000 cubic feet per hour; that the windows had been partially opened during the session, and that the air of the room had been pretty thoroughly changed at recess. In fact, the conditions here for ordinary "good ventilation," so called, were much better than the average.

The result of the air analyses, as shown by the chart, fully bears out the opinion expressed on page 318, in regard to the inadequacy of the means commonly supplied for the ventilation of school-rooms.

Attention is called to the fact that not infrequently the air samples taken just before or at the opening of school in the morning were shown to contain carbonic acid in decided quantity. This appears in charts A, C and H, and in some of the determinations not shown in the charts. The contamination without doubt arose from the fires, which were kept burning all night, the rooms, with all inlets and outlets, being closely shut up. The presence of carbonic acid in the amount indicated might not be of itself harmful; but when it is understood that carbonic acid escaping under such circumstances into the room is almost certain to be accompanied by the deadly carbonic oxide, the matter is seen to be one of some importance. The observer noticed on one or two occasions the smell which indicates the presence of coal gas.

It is plain that when fires are kept burning in a school-room all night, the air of the room should be completely changed in the morning before the opening of school. This, indeed, would not be a bad rule to follow under all circumstances. The rapidity with which one of the ventilated rooms may be made to clear itself of air containing such

impurities may be seen in chart A, where the black line starting from a point above eleven, runs sharply down to a point below five, in a space representing a little more than ten minutes.

Humidity. — No attempt has been made to supply moisture to the air of the ventilated school-rooms, and there has been no complaint of discomfort from the dryness. In respect to the humidity of the air there is no material difference between the ventilated and the unventilated rooms.

To introduce air from out of doors, at the same time raising its temperature thirty degrees or more, as is done in our school-rooms during a portion of the year, is to increase very largely its capacity for moisture, and to lower correspondingly its relative humidity, or percentage of saturation, which, inversely, is the measure of its drying power. An increase of 27° F. in the temperature of air doubles its capacity for moisture.

An inspection of the tables given in connection with the charts will illustrate these statements, although an exact estimate of the change caused by a given rise in temperature is not possible, owing to a lack of precise correspondence in the times and places of observation.

This great increase in the drying power of the air, which, owing to the necessity of heating it, is unavoidable, has been represented as an evil of considerable magnitude by some writers on sanitary subjects. Such appears also to be the popular belief. It is almost universally understood that to keep a shallow pan of water upon the top of a stove, for the purpose of supplying moisture to the air, is a wise procedure. In regard to this point the writer agrees fully with Dr. Billings, who argues against the theory that simple dryness of the air is harmful, and expresses the belief that the ill effects usually ascribed to it arise in fact from a lack of sufficient ventilation, from a contamination of the air with carbonic oxide, or from overheating. In regard to the necessity and practicability of supplying moisture by artificial means he uses the following language : —

"It is evident, therefore, that it is not necessary to supply moisture enough to heated air to bring the percentage up to 70. It is also to be noted that it will take about the

same amount of fuel, or, in other words, will cost as much to furnish this percentage of moisture to air heated from 32° F. to 70° F. as it does to heat the air. Moreover, in a room properly ventilated, under such circumstances, it would be practically almost impossible to maintain such a percentage of moisture, owing to the great rapidity with which the vapor of water diffuses in such a dry air, and the condensation which would occur on windows and thin outer walls."*

Temperature. — The fear has been expressed that when supplying so much fresh air it would be found difficult to keep up the heat, or to diffuse it uniformly through the room. This would doubtless be the case if only one stove were used; but with two, the experience in Lynn has proved that there need be little trouble even in the coldest weather.

The temperature lines of the charts are based on observations taken at the breathing line of the pupils, and at such times as to accentuate the changes produced by the opening of doors in the morning and at recess. In the tables which follow, two of the ventilated are compared with two of the unventilated schoolhouses. To make the comparison exact the observations should have been taken on the same day, and under precisely similar conditions. This was not possible with one observer, and limited time for the work. The thermometers in the front of the room were in all instances placed as far away from the stoves as practicable, in order to avoid the effect of the direct heat. In the ventilated rooms, as there are two stoves in front, the thermometers could not be placed so far away from them as in the unventilated rooms. For this reason the most marked inequalities of temperature in the unventilated rooms are not exhibited in the tables, and the differences between the front and the rear are made to appear less relatively than they really are.

In all the tables allowance should be made for the low temperature shown at 9 and 10.30 o'clock, particularly on the very cold days. It is accounted for by the entrance of cold air through open doors at the opening of school and at recess.

* The Principles of Ventilation and Heating, and their Practical Application. By John S. Billings, M.D., LL D. (Edinb.), Surgeon U. S. A. New York, 1884. Page 59.

Red Rock Street Schoolhouse, Lower Room, March 5, 1888.

Heights above floor.		9.00		9.30		10.00		10.30		11.00		11.30	
Ft.	In.	Front.	Rear.	Front.	Rear.	Front.	Rear.	Front.	Rear.	Front.	Rear.	Front.	Rear.
0	2	56.5	–	60	58	64.5	60	62	60	66	62.5	63	61.5
2	11	60	–	67.5	64	70	65	67.5	65	70.5	66.5	67	65
9	11	85	–	91	76	92	76	87	76	88	76.5	81	72

Temperature outside, 16° to 29°. Strong northwest wind.

Red Rock Street Schoolhouse, Upper Room, Feb. 25, 1888.

0	2	71	65.5	71	68	67	67	65.5	66	63	64	65	65
2	11	73.5	71.5	74	72.5	70	69.5	68	68.5	65.5	66	67	67.5
10	4	83.5	81	80	78	74	72.5	70.5	70	67	68	74	72

Cloudy day. Wind from southeast, brisk. Temperature outside, 35°.

Jackson Street Schoolhouse, Lower Room, Feb. 27, 1888.

0	2	56	52.5	59	55	60	56	52.5	53.5	61	56.5	65	60
2	11	61	59	64	62	65.5	63.5	56.5	56	68.5	65	74	70
10	4	77	71.5	76.5	72	78	73	78.5	73.5	87.5	82.5	88	83

Clear day. Light westerly wind. Temperature outside, 14° to 16°.

George Street Schoolhouse, Lower Room, March 6, 1888.

0	2	49	49	56	53	56.5	56	49.5	48	56	56	56.5	56
2	11	56	57	67.5	63.5	67	65	58.5	53	66	64.5	65	63
8	7	76	75	79	77	76	73.5	80	79	75	74	73	72

Cloudy day. Light westerly wind. Temperature outside, 20° to 26°.

George Street Schoolhouse, Upper Room, Feb. 28, 1888.

0	2	55.5	51	59	53.5	61	55.5	53.5	49.5	64.5	58	61	56
2	11	63	58.5	64	61	65.5	62	58	54.5	69.5	66	66.5	63.5
10	4	79	72	74	70	74.5	70	74	70	83	78	78	74

Light wind. Temperature outside, 14° to 16°.

Chase Avenue Schoolhouse, Lower Room, March 14, 1888.

0	2	59	57.5	63	60	63.5	61	63.5	60	67.5	63.5	65.5	63.5
2	11	63.5	62	67	64.5	66.5	65	68.5	65	72	68.5	68.5	67.5
10	4	72	70	73	70	71.5	69	83	77	83	78	72	70

Cloudy and snowing. Light wind from northeast. Temperature outside, 36° to 38°.

Schoolhouses — Average Temperatures.

	Averages of Observations taken at 9.00, 9.30, 10.00, 10.30, 11.00 and 11.30.*						Average of Observations taken at 9.30, 10, 11 and 11 30.		
	Temperature at floor.	Temperature at breathing line.	Temperature near ceiling.	Difference between floor and breathing line, front of room.	Difference between floor and breathing line, rear of room.	Difference between floor and breathing line, for whole room.	Temperature at floor.	Temperature at breathing line.	Temperature near ceiling.
Red Rock Street, lower room, March 5, 1888,	61.3	66.2	81.9	5.1	4.7	4.9	61.9	67.5	81.6
Jackson Street, lower room, Feb. 27, 1888, .	57.3	63.8	78.4	6.	7.	6.5	59.1	66.6	80.1
George Street, lower room, March 6, 1888,	53.5	62.2	75.8	9.4	8.	8.7	55.8	65.2	74.9
Chase Avenue, lower room, March 14, 1888,	62.3	66.5	74.0	4.	4.5	4.2	63.4	67.4	73.3
Red Rock Street, upper room, Feb. 25, 1888, .	66.5	69.4	74.2	2.6	3.3	2.9	66.2	69.	73.1
George Street, upper room, Feb. 28, 1888,	56.5	62.6	74.7	5.3	7.	6.1	58.5	64.7	75.2

A comparison of the above tables with the statement of averages and differences which follows will convince any one that, so far as heating is concerned, the advantage is decidedly with the ventilated school-rooms. Were the temperature within eight or ten feet of the unjacketed stoves shown, this advantage would be still more plainly manifest. The character of the weather should in every instance be considered. Aside from the temperature, it is much more difficult to keep a building warm on windy than on quiet days. Compare the lower room of the Red Rock Street schoolhouse with that of the George Street schoolhouse. The outside temperature was nearly the same on the days when the observations were made. In the case of the former the floor temperature averages 61.3°; of the latter 53.5°, a difference of 7.8°. The difference between the floor and breathing line is 3.8° greater at the George Street than at the Red Rock Street schoolhouse. A comparison of any one of the ventilated with one of the unventilated rooms in the above table would give similar figures.

The Baltimore Street schoolhouse is to be considered by itself. The numerous observations which have been made are shown in the following tables: —

* Including observations at opening of school and at recess.

Baltimore Street Schoolhouse, Lower Room, Feb. 13, 1888.

Heights above floor. Ft.	In.	9.00 Front.	9.00 Rear.	9.30 Front.	9.30 Rear.	10.00 Front.	10.00 Rear.	10.30 Front.	10.30 Rear.	11.00 Front.	11.00 Rear.	11.30 Front.	11.30 Rear.
0	2	51.5	51	57.5	56	59.5	58.5	57	59	59.5	59.5	61	61
2	11	61.5	63	69.5	71	70.5	73.5	67	69.5	69	72.5	70	74
10	4	78	81	87	94	80.5	83.5	77.5	80.5	77	82.5	77	82.5

Clear day. Wind from north, fresh. Temperature outside, 7° to 18°.

Baltimore Street Schoolhouse, Feb. 18, 1888.

Heights above floor. Ft.	In.	9.00 Lower Room front.	9.00 Upper Room front.	9.30 Lower Room front.	9.30 Upper Room front.	10.00 Lower Room front.	10.00 Upper Room front.	10.30 Lower Room front.	10.30 Upper Room front.	11.00 Lower Room front.	11.00 Upper Room front.	11.30 Lower Room front.	11.30 Upper Room front.
0	2	56	62	58	63	59	62	42	59	56	61.5	60	67
2	11	66	72	66	69	65.5	66.5	58	63.5	68	70	68.5	73
10	4	79	81	74	72	71	67	74	71	82	87	74.5	–

Clear-cloudy. Wind from northwest, fresh. Temperature outside, 25° to 35°.

Baltimore Street Schoolhouse, Feb. 23, 1888.

0	2	58	61.5	61	63	61.5	65	47	64	58	66	59	65.5
2	11	69	66	73	67.5	72.5	69.5	63.5	68.5	68	71	69	69
10	4	78	69.5	81	73	76.5	77	73	83	72.5	77	74	71

Morning opened clear and became cloudy. Light wind from west. Temperature outside, 29° to 38°.

Baltimore Street Schoolhouse — Average Temperatures.

	Averages of Observations taken at 9, 9.30, 10.00, 10.30, 11.00 and 11.30.*						Averages of Observations taken at 9.30, 10 00, 11 00, and 11.30.					
	Temperature at floor.	Temperature at breathing line.	Temperature near ceiling.	Difference between floor and breathing line, front of room.	Difference between floor and breathing line, rear of room.	Difference between floor and breathing line, for whole room.	Temperature at floor.	Temperature at breathing line.	Temperature near ceiling.	Difference between floor and breathing line, front of room.	Difference between floor and breathing line, rear of room.	Difference between floor and breathing line, for whole room.
Lower room, Feb. 13, 1888, . .	57.6	69.3	81.8	10.2	13.1	11.7	59.1	71.3	83	10.4	14	12.2
Lower room, Feb. 18, 1888 (observation in front only), . .	55.2	65.3	75.7	10.2	–	–	58.3	67	75.4	8.8	–	–
Lower room, Feb. 23, 1888 (observation in front only), . .	57.4	69.2	75.8	11.8	–	–	59.9	70.6	76	10.9	–	–
Upper room, Feb. 18 (front only), .	62.3	69	75.6	6.6	–	–	63.4	69.6	75.3	6.3	–	–
Upper room, Feb. 23 (front only), .	64.2	68.6	75.1	4.4	–	–	64.9	69.3	74.5	4.4	–	–

* Including observations at opening of school and at recess.

It must be admitted that in some respects the showing in the case of the lower room is not as favorable as with the other ventilated rooms, for the floor temperature is too low, and there is much too great a difference between this temperature and that of the breathing line.

But notwithstanding this the floor is, as a rule, several degrees warmer than the floors of the unventilated rooms, while it is warm enough at the breathing line. In all other respects this building compares favorably with the others.

The fault with it is undoubtedly one that has been before alluded to, viz.: that, owing to defect in structure, cold air is admitted by channels not provided for it, keeping the floor cold. The defect is one which a carpenter can remove.

The fact that the floor temperature in the front of the room is, on the average, higher than that in the rear, seems to prove that the position of the stoves has nothing to do with the difficulties experienced.

Air-Meter Tests.—These were all made with one of Casella's anemometers, the accuracy of the instrument having been determined by comparison with the one in use at the United States Signal Service Station in Boston.

Where circumstances are favorable, as at the Red Rock Street and the Baltimore Street schoolhouses, it is easy to ascertain with substantial accuracy the air supply, by measuring the outflow. Where the outlets are numerous and scattered but little reliance can be placed upon this test.

In the unventilated rooms the air movements are so variable that, usually, no determination of outflow or inflow can be made. The observations taken at the George Street schoolhouse, lower room, on March 24, 1887, are exceptional, and probably show very nearly the true air supply of the room. Those taken in the upper room on the same date evidently show a result which falls far below the reality.

It is satisfactory to note a general correspondence between the results of the air-meter tests and those of chemical analysis, as thus they become mutually confirmatory. For instance, in the Red Rock Street schoolhouse, lower room, where the supply is shown to be very large, the chemical tests prove that the air is practically as pure as that out of

doors, while in the upper room, where the supply is less (the pupils also being older), the air is shown to be less pure, although the amount of carbonic acid comes well within the limits ascribed to good ventilation.

Advantages of the System. — The advantages of this system of heating and ventilating school-rooms may be briefly summarized as follows: —

1. It is extremely simple, and can be easily applied to that large class of school buildings which it is convenient or practicable to heat by stoves only.

2. When the conditions of success are observed, it is possible to secure perfect, or nearly perfect, ventilation by this method.

3. The position of the stoves in the school-room prevents any waste of heat. When arranged as at the Red Rock Street schoolhouse the whole apparatus is under the immediate supervision of the teacher, who can attend to it without leaving the room.

4. The heating of the rooms is more satisfactory than with the unjacketed stove, or the hot-air furnace. The disadvantages of the stove, as commonly used, are well known. No provision is made for a supply of fresh air, and the temperature is very unequal in different parts of the room. The ordinary furnace supplies a small amount of highly heated air. When the heat becomes too great, registers are closed, and the fresh air supply, what there is of it, is thus shut off. By the jacketed stoves, as used in Lynn, a large amount of moderately heated air is furnished, and there is little danger of over-heating. The jackets around the stoves protect those sitting near from the direct or radiant heat.

Expense of the System. — This includes the cost of construction and of maintenance. The cost of the improvements at the Red Rock Street schoolhouse was $567.77; of those at the Baltimore Street schoolhouse, $554.56. At the Chase Avenue schoolhouse $418.16 was originally expended, but subsequent changes considerably increased the cost. Quite a large part of the first cost came from the necessary

tearing down and building up again. It is notoriously expensive to make changes in completed buildings. The schoolhouse mechanic, who has had a general oversight of the work of making these improvements, estimates that if put in during the process of construction the apparatus in a two-room building would not cost more than $350; in a one-room building $225. The changes could probably be made in an old one-room building for $350. When the arrangements form part of the original plan of a schoolhouse, they are likely to be much more satisfactory than when added afterwards.

The cost of maintenance involves an increased outlay for janitor service and for fuel. In country districts where the fires are cared for by the voluntary service of teacher and pupils the former item is not to be reckoned. In Lynn an extra allowance of fifty cents per week for each additional stove is made during the season when the fires are in operation. This amounts to something near $40 per year for each building of two rooms.

From our experience thus far it is difficult to form an exact estimate of the increased cost of fuel. The coal and wood are supplied to the city on contract, the bins being filled up when necessary. It is certain that the consumption of fuel increases somewhat in proportion to the amount of fresh air supplied. At the Chase Avenue schoolhouse, as nearly as can be ascertained, from five to six tons more of coal have been burned each year since the ventilating apparatus was put in than before. It would be not far from the truth if we should reckon the increased cost of fuel for the building at $30 per year, or $15 for each room. This added to the increased outlay for janitor service makes $35 per room, — surely not an extravagant sum to pay for anything so necessary to health as pure air.

The Conditions of Success.— 1. The first point to be mentioned under this head is that the building should be of good construction. It is not uncommon for schoolhouses to admit air freely, not only around doors and windows, but even directly through the walls. Such a defect in structure is a serious obstacle to the success of this plan of heating

and ventilating. Brick is a better material for walls than wood, because it is not so good a conductor of heat. In the case of wooden buildings a layer of tarred paper under the clapboards and back-plastering the walls are suggested as expedients for keeping air out and heat in. Double windows, or windows with double frames, might be used. Floors should be double and well laid. The underpinning should be tight, and there should be no dampness under the building. When an old schoolhouse is to be ventilated in this way, a few hundred dollars might, in many instances, be profitably spent in the direction indicated above.

2. The extraction flues should be of a size proportionate to the amount of air to be removed. Those at the Red Rock Street schoolhouse are suggested as models. In order to produce a satisfactory draught in them it is necessary that they receive a larger amount of heat than that derived from the smoke pipes. If a stove be used for this purpose, as in Lynn, it should be set into the partition between the flues in such a way as to supply an equal amount of heat to each. The partition between the flues should be made tight around the stove. When the fire is in operation the door into the chimney should be kept shut. Other methods of heating the flues might be used,—a gas-jet, for instance. The experiment of using kerosene-burners at the Chase Avenue schoolhouse was abandoned on account of the disagreeable smell produced.

3. The foul air should be discharged into the flue at the bottom, or at any rate below the place where the flue-heating stove or burner is placed. The attempt at the Chase Avenue schoolhouse to produce a draft by applying heat at the bottom of the flues, while the foul air was let into them at the floor level of the rooms, did not prove satisfactory. Indeed, a theoretical study of the problem might have shown that this was likely to be the case; for such an arrangement would necessitate an ascending and a descending current of air, with more or less of irregular movement and conflict, in the lower part of the flues.

4. The combined area of the outlets from the rooms into the flues, making allowance for registers, wire netting and other means of obstruction, should be somewhat greater

than that of the extraction flue on cross section. They should open as directly as possible into the flue, or into the duct leading to it. To take the foul air from numerous openings, or from different parts of the room, materially impedes the outflow, while it does not appear to aid in the distribution of the pure air.

5. The stoves should be situated near the sides of the building, in order that it may not be necessary to convey the cold air for a long distance under the floor. To do this would be to produce more or less coldness of the floor, an evil to be avoided.

6. The inlets should each be large enough for the total air supply of the room, so as to be sufficient when only one stove is in use. The space within the jacket, around the base of the stove, should be equal to the inlet. No air-duct can be considered larger than its smallest part.

7. Lastly, teachers and janitors should be thoroughly instructed in regard to the working of the apparatus. Any scheme of ventilation will prove a failure if not intelligently managed.

Red Rock Street Schoolhouse, Lower Room, March 7, 1887.

TIME.	Number of persons present.	Air temperature (Fahrenheit).	Humidity of air (percentage of complete saturation).	Carbonic acid in air (parts in 10,000).	Discharge of air from room (cubic feet per hour).	Minutes taken to discharge a roomful.	Temperature out of doors.
8.37–40, ...	2	65	26	11.26	–	–	29
8.50–53, ...	50	–	–	4.71	–	–	–
9.00, ...	56	67.5	31	–	–	–	30
9.20–35, ...	58	66.5	36	–	113,700	6	–
9.55–10.00, ...	58	38	–	–	†94,000	7	–
10.05–20, ...	58	–	–	*5.20	–	–	–
10.30–37, ...	4	63.5	42	4.26	–	–	34
10.50–11.05, ...	58	*74	34	–	122,940	5	–
11 10, ...	57	69.5	–	–	–	–	–
11.18–30, ...	57	71.5	38	–	120,060	6	–
11.35–45, ...	56	69	39	*4.82	–	–	34

* Mean of two measurements. † About.

Clear day. Wind from northwest, fresh.
At Water Office, 8 A.M. — Barom., 30.33; D. B., 26.5; W. B., 25.5; Humid., .88.
" " 1 P.M. — Barom., 30.31; D. B., 32.0; W. B., 30.5; Humid., .83.

Red Rock Street Schoolhouse, Lower Room, March 7, 1887.

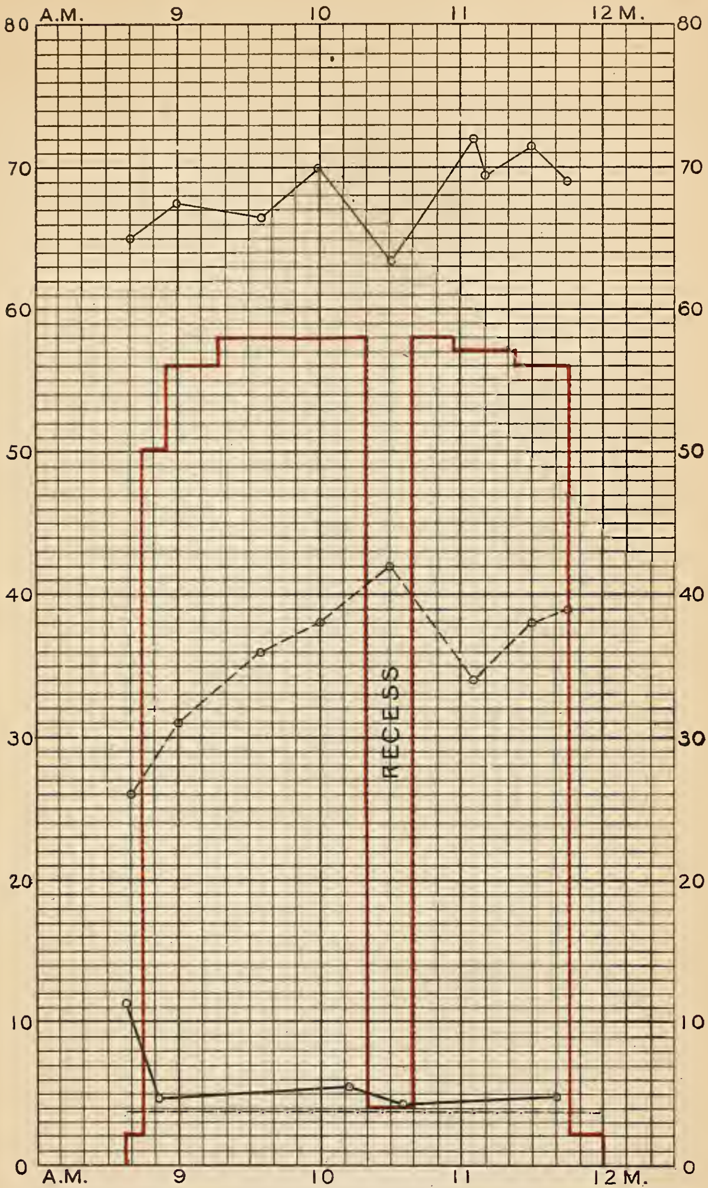
TIME.	
8.40, . .	Foul air outlets all open. Fresh air inlets closed.
8.45, . .	Scholars came in. Teacher opened inlets one-half each.
8.50, . .	Inlets opened wide.
9.20–33, .	Air currents measured at all outlets. Rate of discharge, 113,700 cubic feet per hour, or the roomful in six minutes.
9.40, . .	Standing by northwest stove-jacket observer felt cool air on his head. Fire low. Same at southeast jacket.
9.43, . .	Calisthenics. Teacher opened northwest window, near door, also both doors into entry. Observer half-closed both inlets.
9.45, . .	Windows and doors closed.
9.55, . .	Measurements at two outlets indicated a discharge of about 94,000 cubic feet per hour, or the roomful in about seven minutes.
10.20, . .	Recess begun. Three scholars stayed in. Draft of ventilating apparatus increased. Both inlets opened wide.
10.40, . .	Recess ended.
10.55, . .	Measurements at all outlets. Rate of discharge, 122,940 cubic feet per hour, or the roomful in five minutes.
11.10, . .	Half-closed both inlets. Quickened fire in northwest stove a little.
11 18–30, .	Measurements at all outlets: rate of discharge, 120,060 cubic feet per hour, or the roomful in six minutes.
11.45, . .	School dismissed.

Contents of room, 10,700 cubic feet. Air space for each of 67 scholars, 160 cubic feet. Average age of scholars, 7 years, 9 months.

A

RED ROCK STREET SCHOOL HOUSE LOWER ROOM

OBSERVATIONS MARCH 7TH 1887.



_._._._ *Carbonic Acid in Pure Air, parts in 10000.*

——— " " *parts in 10000* } *in school room*

– – – – *Relative Humidity*...............

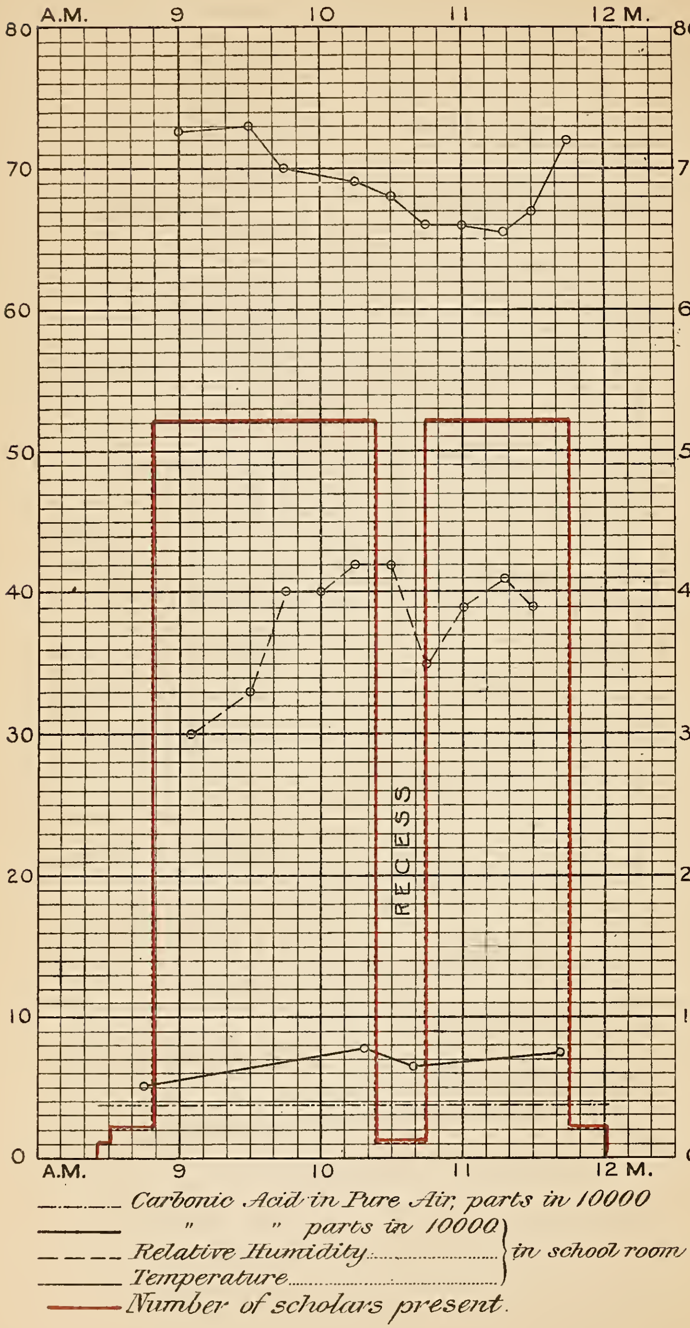
——— *Temperature*...............

——— *Number of scholars present*

B

RED ROCK ST. SCHOOL HOUSE UPPER ROOM

FEBRUARY 25TH 1888.



Red Rock Street Schoolhouse, Upper Room, Feb. 25, 1888.

TIME.	Number of persons present.	Air temperature (Fahrenheit).	Humidity of air (percentage of complete saturation).	Carbonic acid in air (parts in 10,000).	Rate of disch'ge from outlets (cubic feet per hour).	Temperature out of doors.
8.45, ...	1	73	-	5.10*	-	35
9.00, ...	52	72.5	30	-	-	-
9.30, ...	52	73	33	-	-	-
9.45-50,.	52	70	40	-	89,478	-
10.00, ...	52	69.5	40	-	-	-
10.15-20,.	52	69	42	7.78*	-	-
10.30, ...	2	68	42	-	-	-
10.40, ...	1	66	-	6.42*	-	-
10.45, ...	52	66	35	-	-	-
10.50, ...	52	-	-	-	90,720	-
11.00, ...	52	66	39	-	-	-
11.18, ...	52	65.5	41	-	-	-
11.30, ...	52	67	39	-	-	-
11.42, ...	52	70	-	7.46*	-	-
11.45, ...	52	72	33	-	-	-
12.07, ...	-	-	-	-	-	36

* Mean of two samples.

Wind from northwest, fresh.

Office of Water Board, Feb. 25, 8 A. M. — Barom., 30.16; D. B., 35; W. B , 33.5; Humid., 73.
" " " " 1 P. M. — Barom., 30.00; D. B., 36; W. B., 34.5; Humid., 84.

Red Rock Street Schoolhouse, Upper Room, Feb. 25, 1888.

TIME.	
6.45, . .	Inlets closed; outlets open.
6.50, . .	Inlets opened.
7.05, . .	Fire built in chimney stove.
8.25, . .	Six windows opened from ten to twenty inches.
8.35, . .	Windows closed.
8.43, . .	Air samples taken in two places in room.
8.48, . .	Scholars came in.
9.50, . .	Air-meter measurements in outlets: indicated discharge, 89,478 cubic feet per hour.
10.18, . .	Air samples taken as before.
10.23, . .	Recess began.
10.39, . .	Air samples taken as before.
10.44, . .	Scholars came in from recess
10.50, . .	Air-meter measurements in outlets: indicated discharge, 90,720 cubic feet per hour.
11.40, . .	Air samples taken as before.
11.46, . .	School dismissed.

Contents of room, 12,040 cubic feet. Air space for each of 66 scholars, 162 cubic feet. Average age of scholars, 9 years, 6 months.

Chase Avenue Schoolhouse, Lower Room, March 31, 1887.

TIME.	Number of persons present.	Air temperature (Fahrenheit).	Humidity of air (percentage of complete saturation).	Carbonic acid in air (parts in 10,000).	Rate of discharge at outlet (cubic feet per hour).	Minutes taken to discharge the roomful.	Temperature out of doors.
8.35–38, ...	2	67	–	9.89	–	–	–
9.30, ...	42	70	20	–	–	–	33
9.40, ...	42	–	–	–	29,760	21	–
10.05, ...	42	–	–	–	–	–	34
10.15, ...	42	–	–	8.46	–	–	–
10.30, ...	2	67.5	29	–	–	–	35
10.37–40, ...	2	66	–	4.33	–	–	–
10.55, ...	41	–	–	–	–	–	36
11.35–40, ...	41	69	29	8.00	–	–	38.5
11.53, ...	2	67	33	–	–	–	40

Clear day. Wind from north northwest, strong.
At Water Office, 8 A.M. — Barom., 29.93; D. B., 25.5; W. B., 22.0; Humid., .56.
" " 1 P.M. — Barom., 30.00; D. B., 39.0; W. B., 36.0; Humid., .73.

Chase Avenue Schoolhouse, Lower Room, March 31, 1887.

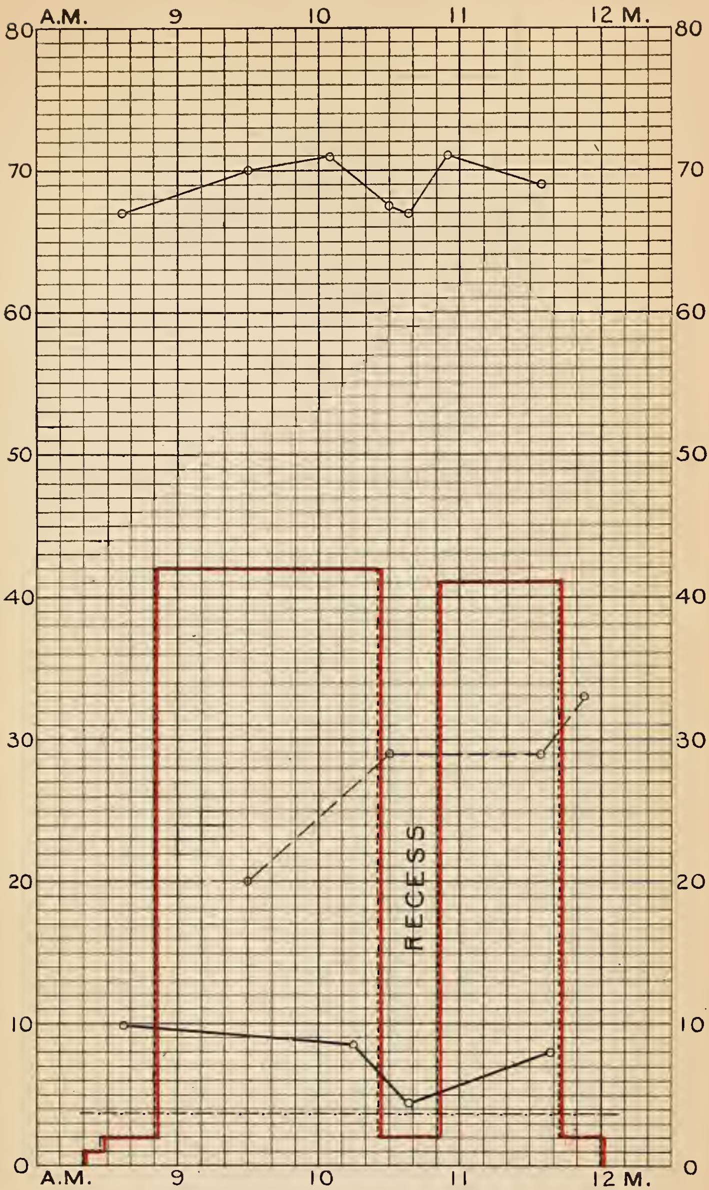
TIME.	
8.33, . .	Platform outlets all open. Inlets partly open. Two fires burning. Teacher opened both inlets wide.
8.50, . .	Scholars came in.
9.40, . .	Air currents at platform outlets measured: rate of discharge, 29,760 cubic feet per hour, or the roomful in twenty-one minutes.
10.25, . .	Recess began.
10.30, . .	Teacher opened southeast (leeward) window, lower sash, about two feet.
10.35, . .	Found fire in chimney stove low, and replenished it.
10.40, . .	Teacher closed window to within three inches of bottom.
10.50, . .	Recess ended. Window fully closed.
11.05, . .	Quickened fire in chimney stove. Observed that mortar had fallen out of the partition between flues, at the stove, leaving a space about 24 × 3 inches.
11.42, . .	School dismissed.

Contents of room, 10,400 cubic feet. Air space for each of 42 scholars, 248 cubic feet. Average age of scholars, 7 years, 5 months.

C

CHASE AVENUE SCHOOL HOUSE LOWER ROOM

MARCH 31ST 1887



—·—·— *Carbonic Acid in Pure Air, parts in 10000*

——— " " *parts in 10000* } *in school room*

– – – *Relative Humidity* } *in school room*

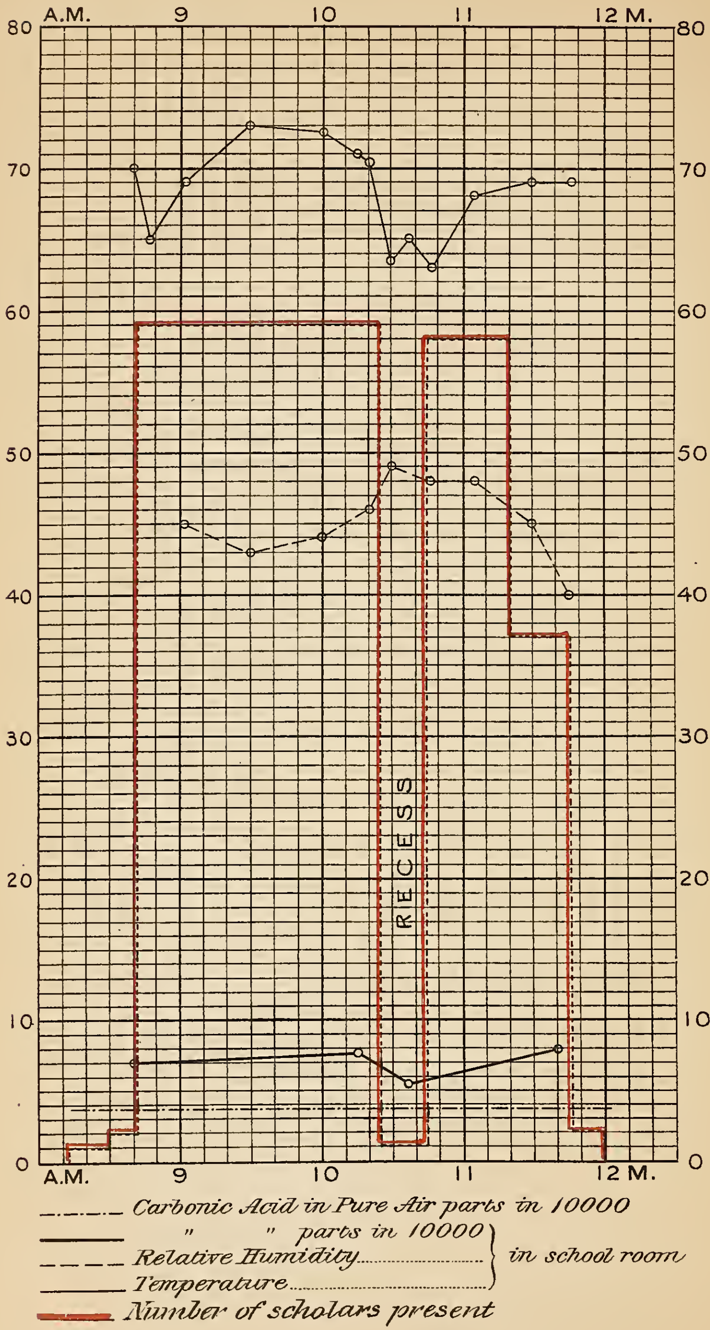
——— *Temperature* } *in school room*

——— *Number of scholars present*

D

BALTIMORE ST. SCHOOL HOUSE LOWER ROOM

FEBRUARY 23º 1888.



Baltimore Street Schoolhouse, Lower Room, Feb. 23, 1888.

TIME.	Number of persons present.	Air temperature (Fahrenheit).	Humidity of air (percentage of complete saturation).	Carbonic acid in air (parts in 10,000).	Rate of disch'ge from outlets (cubic feet per hour).	Temperature out of doors.
8.40, ...	2	70	–	7.13	–	31
8.47, ...	59	65	45	–	–	–
9.02, ...	59	69	45	–	–	–
9.16, ...	59	–	–	–	67,140	–
9.30, ...	59	73	43	–	–	–
10.00, ...	59	72.5	44	–	–	–
10.15, ...	59	71	–	7.71	–	–
10.20, ...	59	70.5	46	–	–	–
10.30, ...	1	63.5	49	–	–	–
10 37, ...	1	65	–	5.47	–	–
10.47, ...	58	63	48	–	–	–
10.50, ...	58	–	–	–	68,712	–
11.05, ...	58	68	48	–	–	–
11.30, ...	37	69	45	–	–	–
11.40, ...	37	69	–	7.96	–	–
11.46, ...	2	69	40	–	–	–

Morning opened clear and became cloudy. Wind from west, light.
At Water Board Office, 8 A.M. — Barom., 30.24; D. B., 29.0; W. B., 24.0; Humid., .45.
" " " 1 P.M. — Barom., 30.22; D. B., 38.5; W. B., 37.0; Humid., .86.

Baltimore Street Schoolhouse, Lower Room, Feb. 23, 1888.

TIME.	
6.35, . .	School-room completely shut up.
6.45, . .	Fires quickened. Inlets and outlets opened.
8.15, . .	Four windows opened from six to twenty-four inches.
8.30, . .	Windows closed.
8.40, . .	Took air sample.
8.42, . .	Scholars came in.
9.16, . .	Air-meter measurement at outlets: indicated discharge, 67,140 cubic feet per hour.
10.15, . .	Took air sample.
10.25, . .	Recess began.
10.37, . .	Air sample taken.
10.45, . .	Scholars came in from recess.
10.50, . .	Air-meter measurements at outlets: indicated discharge, 68,712 cubic feet per hour.
11.20, . .	Twenty-one scholars dismissed, leaving thirty-five.
11.40, . .	Air sample taken.
11.46, . .	School dismissed.

Contents of room, 10,860 cubic feet. Air space for each of 59 scholars, 184 cubic feet. Average age of scholars, 6 years, 8 months.

Baltimore Street Schoolhouse, Upper Room, Feb. 23, 1888.

TIME.	Number of persons present.	Air temperature (Fahrenheit).	Carbonic acid in air (parts in 10,000).	Rate of disch'ge from outlets (cubic feet per hour).	Temperature out of doors.
8.13, ...	1	62	–	–	31
8.45, ...	2	65	6.73	–	–
9.02, ...	40	66	–	–	–
9.30, ...	41	67.5	–	–	–
9.35, ...	41	–	–	68,580	–
10.00, ...	41	69.5	–	–	–
10.20, ...	42	71	6.91	–	–
10.30, ...	3	68.5	–	–	–
10.40, ...	4	65	5.62	–	–
11.05, ...	40	71	–	–	–
11.13–25, ...	40	–	–	56,670	–
11.30, ...	40	69	–	–	–
11-43, ...	40	–	5.80	–	–

Morning opened clear and became cloudy. Wind from west, light.
At Water Office, 8 A. M. — Barom., 30.24 ; D. B., 29.0 ; W. B., 24.0 ; Humid., .45.
" " 1 P. M. — Barom., 30.22 ; D. B., 38.5 ; W. B., 37.0 ; Humid., .86.

Baltimore Street Schoolhouse, Upper Room, Feb. 23, 1888.

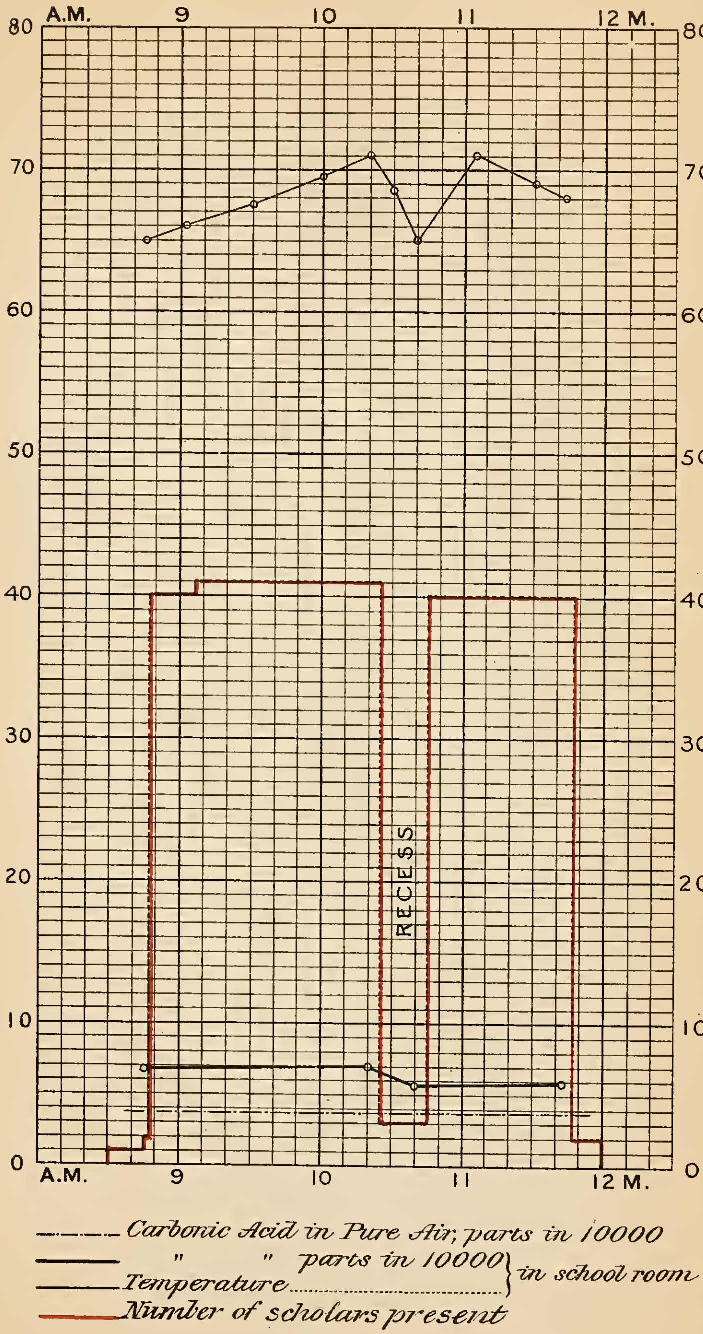
TIME.	
6.35, . .	Schoolhouse wholly shut up. Opened inlets and outlets (except top outlets). Quickened fires.
8 13, . .	Opened four windows from six to twenty-four inches each.
8.42, . .	Closed windows wholly.
8.45, . .	Air sample taken in middle of room at breathing line.
8.47, . .	Scholars came in.
9.06, . .	One scholar came in.
9.35, . .	Air-meter measurements at outlets: indicated discharge, 68,580 cubic feet per hour.
10.20, . .	Air sample taken in middle of room at breathing line.
10.25, . .	Recess began ; two scholars stayed in.
10.40, . .	Air sample taken ; same place as above.
10.45, . .	Scholars came in from recess.
11.13–25, .	Air-meter measurements at outlets: indicated discharge, 56,670 cubic fee per hour.
11.20, . .	Twenty-one scholars dismissed, leaving thirty-five.
11.43, . .	Air sample taken in same place as above.
11.47, . .	School dismissed.

Contents of room, 10,740 cubic feet. Air space for each of 42 scholars, 256 cubic feet. Average age of scholars, 9 years, 3 months.

E

BALTIMORE ST. SCHOOL HOUSE UPPER ROOM

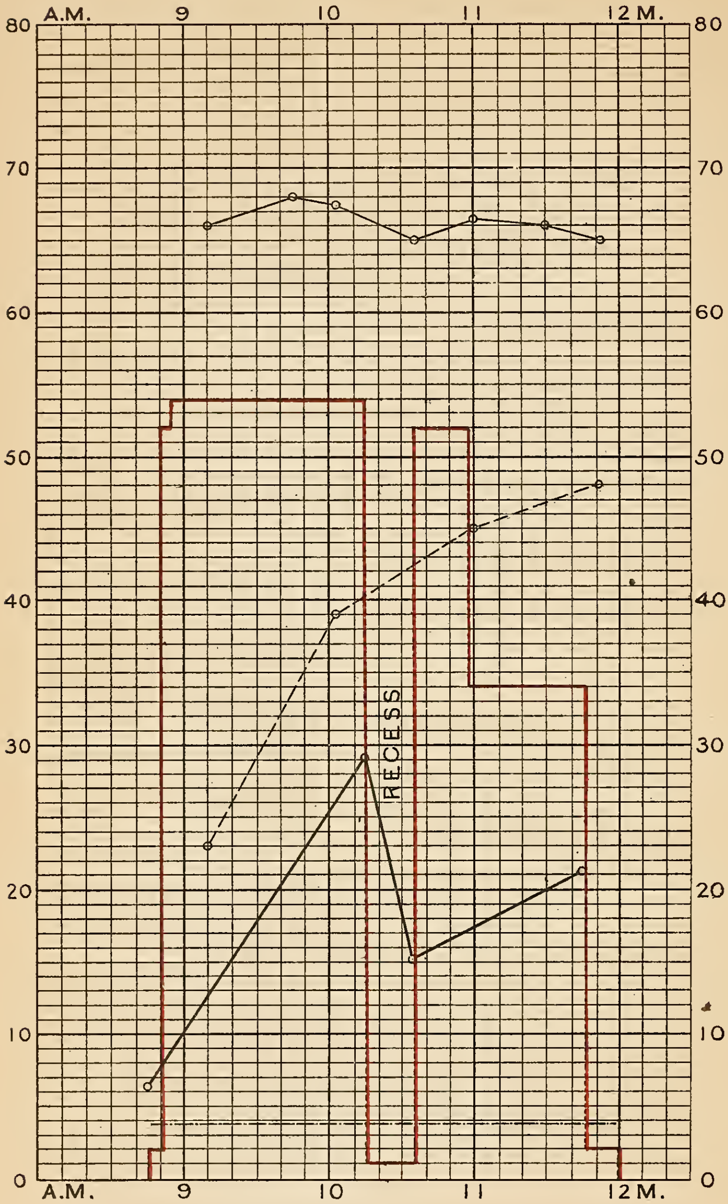
FEBRUARY 23° 1888.



F

JACKSON STREET SCHOOL HOUSE LOWER ROOM

OBSERVATIONS MARCH 16TH 1887.



Carbonic Acid in Pure Air, parts in 10000

" " parts in 10000 } *in school room*

Relative Humidity ....

Temperature ....

Number of scholars present

Jackson Street Schoolhouse, Lower Room, March 16, 1887.

TIME.	Number of persons present.	Air temperature (Fahrenheit).	Humidity of air (percentage of complete saturation).	Carbonic acid in air (parts in 10,000).	Temperature out of doors.
8.42–45, ...	2	55	–	6.39	–
9.10, ...	54	66	23	–	–
9.45, ...	54	68	–	–	–
10.03, ...	54	67.5	39	–	–
10.12–15, ...	54	–	–	29.15	–
10.32–35, ...	1	65	–	15.19	–
11.00, ...	34	66.5	45	–	–
11.30, ...	34	66	–	–	–
11.39–42, ...	34	–	–	21.29	–
11.52, ...	2	65	48	–	35

Cloudy day; light wind.
At Water Office, 8 A.M. — Barom., 29.97; D. B., 23.5; W. B., 21.5; Humid., .73.
" " 1 P.M. — Barom., 29.97; D. B., 36.0; W. B., 32.0; Humid., .61.

Jackson Street Schoolhouse, Lower Room, March 16, 1887.

TIME.	
8.42, . .	School-room shut up completely.
8.50, . .	Scholars came in.
10.15, . .	Recess began. Doors and windows kept closed during recess, just as during the session. Scholars all went out.
10.35, . .	Recess ended.
10.58, . .	Eighteen scholars (beginners) went home.
11.45, . .	School dismissed.

Contents of room, 7,830 cubic feet. Air space for each of 52 scholars, 151 cubic feet. Average age of scholars, 6 years, 10 months.

Jackson Street Schoolhouse, Upper Room, March 16, 1887.

TIME.	Number of persons present.	Air temperature (Fahrenheit).	Humidity of air (percentage of complete saturation).	Carbonic acid in air (parts in 10,000).	Temperature out of doors.
8.47–50,	2	70	–	5.50	–
9.10,	56	68	–	–	–
9.40,	56	68.5	34	–	30
10.05–10,	56	69	–	27.01	–
10.30,	3	61	–	12.63	–
10.41,	56	62.5	48	–	34
11.00,	56	68	–	–	–
11.28–35,	56	69	48	26.01	35

Cloudy day ; light wind.
At Water Office, 8 A. M. — Barom., 29.97 ; D. B., 23.5 ; W. B., 21.5 ; Humid., .73.
" " 1 P. M. — Barom., 29.97 ; D. B., 36.0 ; W. B., 32.0 ; Humid., .61.

Jackson Street Schoolhouse, Upper Room, March 16, 1887.

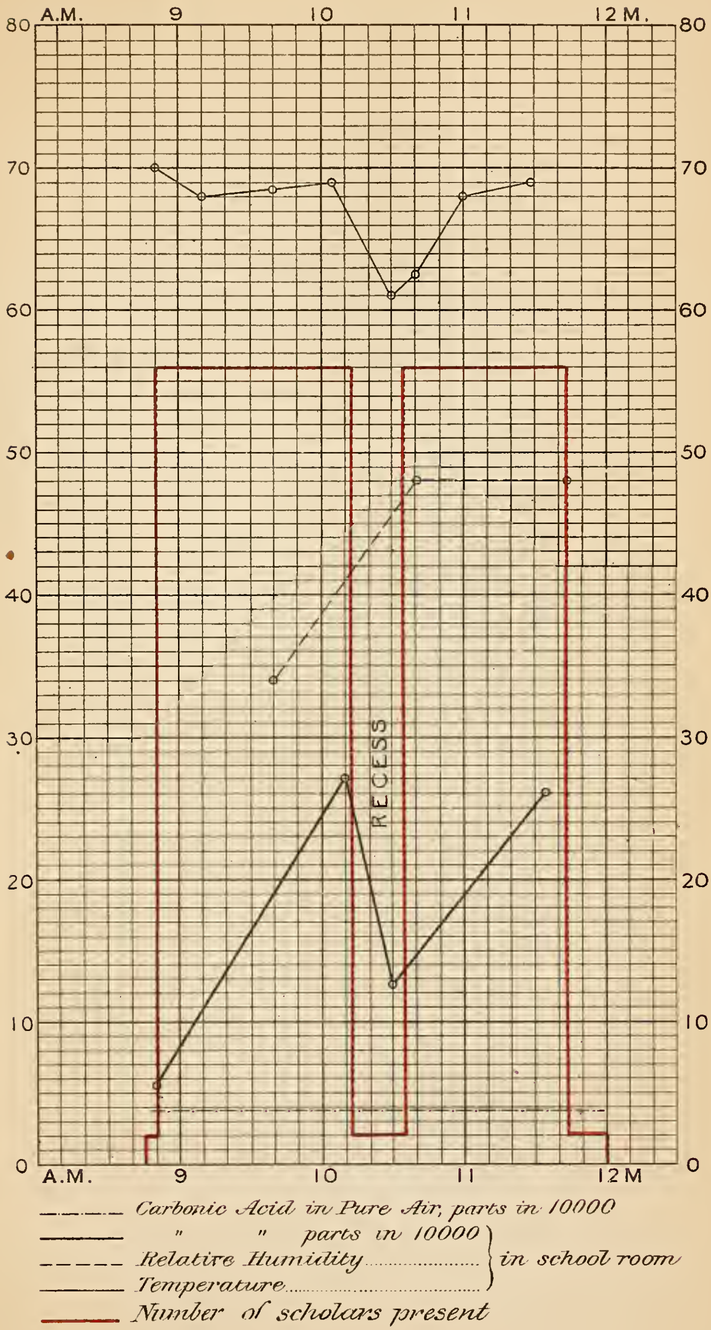
TIME.	
8.45,	School-room completely shut up.
8.50,	Scholars came in.
10.12,	Recess began. Windows kept closed. Both doors into entry open.
10.35,	Recess ended. Doors closed, leaving school-room again completely shut up.
11.43,	School dismissed.

Contents of room, 7,430 cubic feet. Air space for each of 56 scholars, 133 cubic feet. Average age of scholars, 8 years, 11 months.

G

JACKSON STREET SCHOOL HOUSE UPPER ROOM

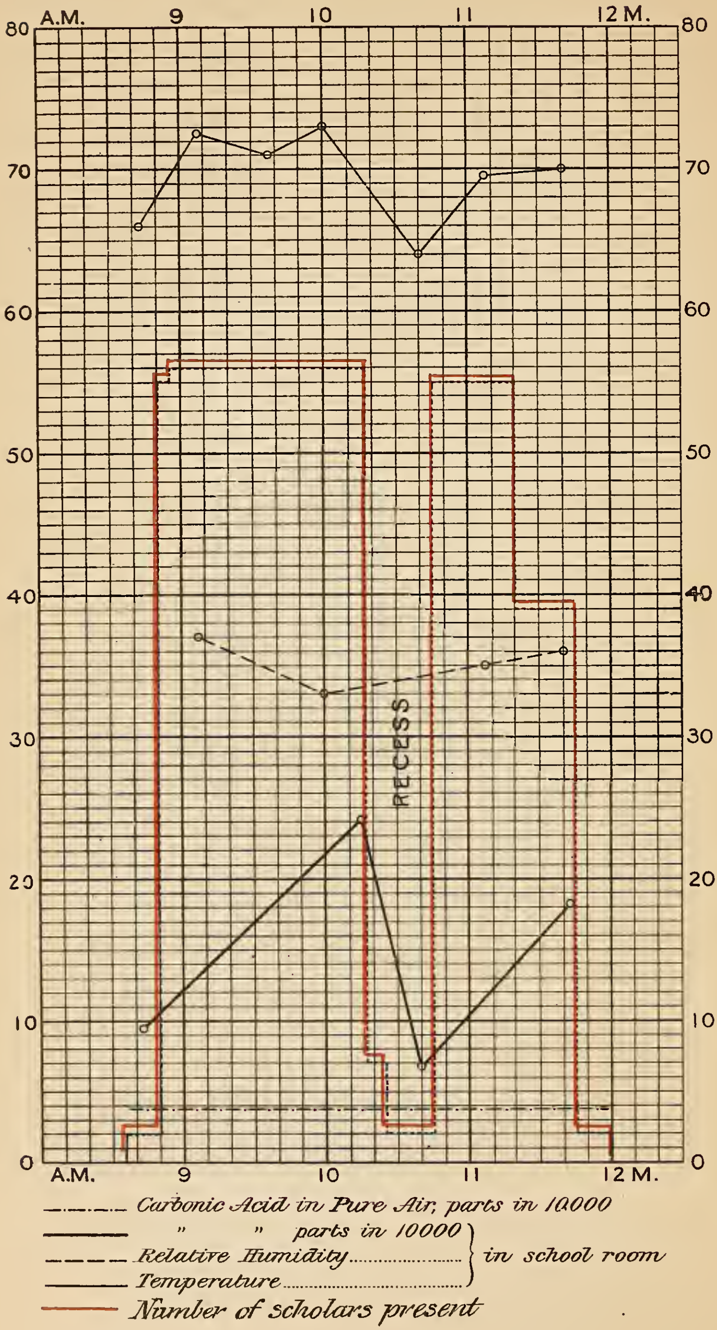
OBSERVATIONS MARCH 16TH 1887.



H

GEORGE STREET SCHOOL HOUSE LOWER ROOM

OBSERVATIONS MARCH 24TH 1887.



George Street Schoolhouse, Lower Room, March 24, 1887.

TIME.	Number of persons present.	Air temperature (Fahrenheit).	Humidity of air (percentage of complete saturation).	Carbonic acid in air (parts in 10,000).	Air discharge at outlets (cubic feet per hour).	Minutes taken to discharge the roomful.	Temperature out of doors.
8.43, ...	2	66	–	9.49	–	–	–
9.07, ...	56	72.5	37	–	–	–	29
9.37, ...	56	71	–	–	–	–	30
9.50, ...	56	–	–	–	10,560*	42	–
10.00, ...	56	73	33	–	2,340†	191	32
10.15, ...	56	–	–	24.06	–	–	–
10.44, ...	3	–	–	6.84	–	–	–
11.01–07, ...	55	69.5	35	–	–	–	35
11.40–43, ...	39	70	36	18.10	–	–	38

* Upper outlet. † Lower outlet.

Clear day. Wind from west northwest, light.
At Water Office, 8 A.M. — Barom., 29.76; D. B., 25.0; W. B., 22.5; Humid., .69.
" " 1 P.M. — Barom., 29.78. D. B., 35.5; W. B., 33.0; Humid., .74.

George Street Schoolhouse, Lower Room, March 24, 1887.

TIME.	
8.50, . .	Scholars came in. Window by stove open three inches at bottom and one inch at top. Two windows on northwest side and two on southeast side open one-half inch each at top. Upper and lower outlets wide open.
9.10, . .	Teacher closed all the windows on northwest side.
9.48–50, .	Air current in upper outlet measured (both outlets being open): rate of discharge, 10,560 cubic feet per hour, or the roomful in forty-two minutes.
9.50, . .	Window by stove closed at the bottom.
9.57–58, .	Air current in lower outlet measured (both outlets open): rate of discharge, 2,340 cubic feet per hour, or the roomful in one hundred and ninety-one minutes.
10.17, . .	Recess began. Five scholars stayed in.
10.25, . .	The five scholars went out. Teacher opened two rear northwest windows and one front southeast window. Door open about half the time, during recess.
10.35, . .	Teacher closed northwest windows, and left southeast windows open, about one inch each.
10.53, . .	Recess ended.
11.45, . .	School dismissed.

Contents of room, 7,400 cubic feet. Air space for each of 56 scholars, 132 cubic feet. Average age of scholars, 7 years.

George Street Schoolhouse, Upper Room, March 24, 1887.

TIME.	Number of persons present.	Air temperature (Fahrenheit).	Humidity of air (percentage of complete saturation).	Carbonic acid in air (parts in 10,000).	Air discharge at outlets (cubic feet per hour).	Minutes taken to discharge the roomful.	Temperature out of doors.
8.48, ...	2	64	–	4.85	–	–	–
9.33, ...	55	71	31	–	–	–	30
10.00–09, ...	55	73	–	27.65	–	–	32
10.30–33, ...	3	59	41	6.61	–	–	33
11.10–17, ...	56	68	–	–	1,800	311	35
11.35–38, ...	56	72	–	20.21	–	–	–

Clear day. Wind from west northwest, light.
At Water Office, 8 A. M. — Barom., 29.76 ; D. B., 25.0 ; W. B., 22.5 ; Humid., .69.
" " 1 P. M. — Barom., 29.78 ; D. B., 35.5 ; W. B., 33.0 ; Humid., .74.

George Street Schoolhouse, Upper Room, March 24, 1887.

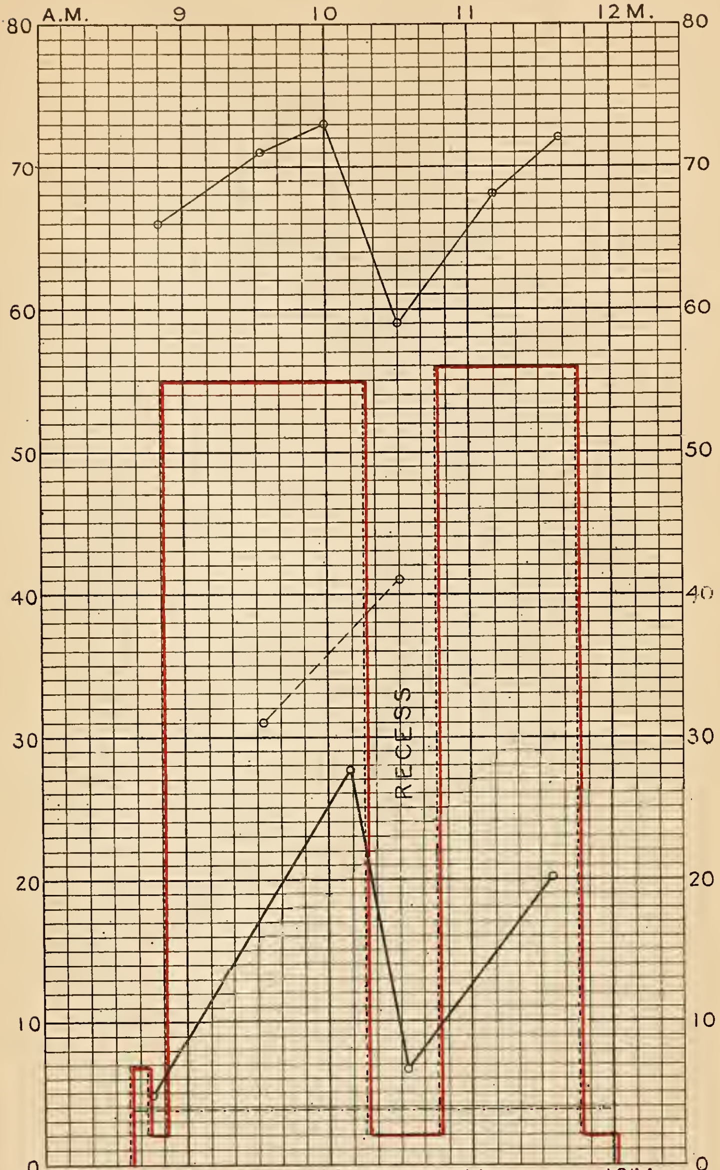
TIME.	
8.50, . .	Scholars came in. Rear northwest window open one inch at top. Front northwest window one inch at bottom. Two rear southeast windows open one inch each at top.
9.35, . .	Door into entry opened four inches to cool room.
10.15, . .	Recess began. Northwest front window and southeast middle window opened to full size of lower sashes.
10.33, . .	Northwest window closed.
10.45, . .	Recess ended. Southeast middle window closed. Front northwest window left open three inches at bottom.
11.17, . .	Air current in lower outlet tried with upper outlet closed. No continuous motion of air meter: discharge per hour estimated at 1,800 cubic feet.
11.20, . .	Upper outlet opened wide. Moderate flow of air outward; had not time to measure it.
11.45, . .	School dismissed.
11.50, . .	Air current in upper outlet tried. Slight *downward* draft, but fitful.

Contents of room, 9,360 cubic feet. Air space for each of 56 scholars, 167 cubic feet. Average age of scholars, 7 years, 3 months.

I

GEORGE STREET SCHOOL HOUSE UPPER ROOM

OBSERVATIONS MARCH 24TH 1887.



_._._._._ *Carbonic Acid in Pure Air, parts in 10000*

———— *" " parts in 10000* }

_ _ _ _ _ *Relative Humidity* .... } *in school room*

————— *Temperature* .... }

———— *Number of scholars present*

Other Observations.

Baltimore Street Schoolhouse, Lower Room, Feb. 13, 1888.

TIME.	Number of persons present.	Air temperature (Fahrenheit).	Humidity of air (percentage of complete saturation).	Carbonic acid in air (parts in 10,000).	Rate of disch'ge from outlets (cubic feet per hour).	Temperature out of doors.
8.00,	1	45	–	–	–	26
8.45–47,	56	56	–	9.85	–	–
9.00,	57	62	–	–	–	–
9.30,	57	70	35	–	–	–
9.50,	–	–	–	–	72,050	–
10.00,	57	72	25	–	–	–
10.11–14,	57	–	–	13.51	–	–
10.30,	6	–	–	7.12	–	–
10.47,	57	68	29	–	–	–
11.05,	59	70	28	–	–	–
11.10–20,	–	–	–	–	65,520	–
11.27,	58	72	28	–	–	–
11.37,	58	74	–	7.79	–	–
11.47,	58	72	32	–	–	–
12.12,	–	–	–	–	–	39.5

Clear day. Wind from north, fresh.
At Water Office, 8 A. M. — Barom., 30.13; D. B., 26.0; W. B., 24.5; Humid., .82.
" " 1 P. M. — Barom., 30.14; D. B., 38.0; W. B., 35.0; Humid., .71.

Baltimore Street Schoolhouse, Lower Room, Feb. 13, 1888.

TIME.	
8.00,	School-room completely shut up; one cellar window out (replaced at once). Opened inlets and outlets. Quickened fires.
8.15,	Opened top outlet (and left it open ten minutes).
8.45,	Scholars came in.
8.47,	Air sample taken in middle of room at breathing line.
9.50,	Air-meter measurements at outlets: indicated discharge, 72,060 cubic feet per hour.
10.11–14,	Air sample taken in middle of room at breathing line.
10.27,	Recess began. Doors left open five or ten minutes.
10.36,	Air sample taken in middle of room at breathing line.
10.47,	Scholars came in from recess.
11.10–20,	Air-meter measurements at outlets: indicated discharge, 65,520 cubic feet per hour.
11.37,	Air sample taken in middle of room at breathing line.
11.47,	School dismissed.

Contents of room, 10,860 cubic feet. Air space for each of 59 scholars, 184 cubic feet. Average age of scholars, 6 years, 8 months.

Baltimore Street Schoolhouse, Upper Room, Feb. 13, 1888.

TIME.	Number of persons present.	Air temperature (Fahrenheit).	Carbonic acid in air (parts in 10,000).	Rate of disch'ge from outlets (cubic feet per hour).	Temperature out of doors.
8.00,	1	62	–	–	26
8.45–47,	42	78	10.50	–	–
9.05,	45	73	–	–	–
9.30,	45	69	–	–	–
9.45,	46	67	–	–	–
10.03,	46	66.5	–	–	–
10.17–19,	46	–	14.45	–	–
10.33,	2	74	–	–	–
10.41–43,	1	67	4.76	–	–
10.55,	45	–	–	73,620	–
11.05,	45	71	–	–	–
11.30,	45	69	–	–	–
11.41–44,	–	–	7.08	–	–
12.12,	–	–	–	–	39.5

Clear day. Wind from north, fresh.
At Water Office, 8 A.M.—Barom., 30.13; D. B., 26.0; W. B., 24.5; Humid., .82.
" " 1 P.M.—Barom., 30.14; D. B., 38.0; W. B., 35.0; Humid., .71.

Baltimore Street Schoolhouse, Upper Room, Feb. 13, 1888.

TIME.	
8.00,	Schoolhouse completely shut up. Opened inlets and outlets (including top outlet). Quickened fires.
8.35,	Closed top outlet.
8.45,	Scholars came in.
8.50–52,	Air sample taken in middle of upper room at breathing line. Opened top outlet.
9.12,	Closed top outlet.
10.03,	Temperature upper room floor, 62.5°; five feet above floor, 66.5°.
10.17–19,	Air sample taken in middle of room at breathing line.
10.27,	Scholars went out at recess. Doors left open five or ten minutes.
10.33,	Temperature of floor, 58°; five feet above floor, 74°.
10.41–43,	Air sample taken in middle of room at breathing line.
10.47,	Scholars came in from recess.
10.55,	Air-meter measurements at outlets: indicated discharge, 73,620 cubic feet per hour.
11.05,	Temperature at floor, 65°; five feet above floor, 71°.
11.30,	Temperature at floor, 66°; five feet above floor, 69°.
11.41–44,	Air sample taken in middle of room at breathing line.
11.50,	School dismissed.

Contents of room, 10,740 cubic feet. Air space for each of 46 scholars, 233 cubic feet. Average age of scholars, 9 years, 3 months.

Baltimore Street Schoolhouse, Lower Room, Feb. 18, 1888.

TIME.	Number of persons present.	Air temperature (Fahrenheit).	Humidity of air (percentage of complete saturation).	Carbonic acid in air (parts in 10,000).	Rate of disch'ge from outlets (cubic feet per hour).	Temperature out of doors.
8.00, ...	–	–	–	–	–	25
8.40, ...	2	65	26	–	–	–
8.43–45,.	60	65	–	10.63	–	–
9.00, ...	60	66	26	–	–	–
9.30, ...	60	66	32	–	–	–
9.35–45,.	60	–	–	–	61,524	–
10.00,*	60	65.5	33	–	–	–
10.15, ...	60	65	–	9.09	–	–
10.30, ...	2	58	35	–	–	–
10.40, ...	2	59	–	5.61	–	–
10.48, ...	60	66.5	28	–	–	–
11.00,*	60	68	26	–	–	–
11.30, ...	60	68.5	34	–	–	–
11.42, ...	60	69	35	8.03	–	–
12.05, ...	–	–	–	–	–	40.5

* Temperature on floor at main outlet, 63°.

Clear-cloudy day. Wind from northwest, fresh.
At Water Office, 8 A.M. — Barom., 29.97; D. B., 25.0; W. B., 24.0; Humid., .87.
" " 1 P.M. — Barom., 29.98; D. B., 35.0; W. B., 33.5; Humid., .84.

Baltimore Street Schoolhouse, Lower Room, Feb 18, 1888.

TIME.	
7.50, . .	Schoolhouse completely shut up. Quickened fires. Opened all inlets and outlets (except top outlets), and opened three windows on each side about fifteen inches each (top and bottom).
8.05, . .	Closed windows.
8.43, . .	Scholars came in.
8.45, . .	Air sample taken in middle of room at breathing line.
9.35–45, .	Air-meter measurements at outlets: indicated discharge, 61,524 cubic feet per hour.
10.15, . .	Air sample taken in middle of room at breathing line.
10.22, . .	Recess began. Doors left open about ten minutes.
10.40, . .	Air sample taken in middle of room at breathing line.
10.45, . .	Scholars came in from recess.
11.25, . .	Air-meter measurements at outlets (two openings only): indicated discharge, slightly larger than before.
11.42, . .	Air sample taken in middle of room at breathing line.
11 50, . .	School dismissed.

Contents of room, 10,860 cubic feet. Air space for each of 60 scholars, 181 cubic feet. Average age of scholars, 6 years, 8 months.

Baltimore Street Schoolhouse, Upper Room, Feb. 18, 1888.

TIME.	Number of persons present.	Air temperature (Fahrenheit).	Carbonic acid in air (parts in 10,000).	Rate of disch'ge from outlets (cubic feet per hour).	Temperature out of doors.
8.00,	–	–	–	–	25
8.47–50,	42	66	10.47	–	–
9.05,	42	72	–	–	–
9.30,	42	69	–	–	–
10.00,	42	66.5	–	–	–
10.20,	42	66	6.75	–	–
10.30,	5	63.5	–	–	–
10.40,	8	63	5.92	–	–
11.00,	42	70	–	–	–
11.05–15,	42	–	–	59,280	–
11.20,	42	74	–	–	–
11.30,	42	73	–	–	–
11.40,	42	72	–	–	–
11.45,	42	71	7.46	–	–
12.05,	–	–	–	–	40.5

Clear-cloudy day. Wind from northwest, fresh.
At Water Office, 8 A.M.—Barom., 29.97; D. B., 25.0; W. B., 24.0; Humid., .87.
" " 1 P.M.—Barom., 29.98; D. B., 35.0; W. B., 33.5; Humid., .84.

Baltimore Street Schoolhouse, Upper Room, Feb. 18, 1888.

TIME.	
7.50,	School-room wholly shut up. Odor of coal-gas. Opened inlets and outlets (except top outlets). Quickened fires. Opened three windows on each side about fifteen inches each.
8.05,	Closed windows.
8.43,	Scholars came in.
8.47–50,	Air sample taken in middle of room at breathing line.
10.20,	Air sample taken in middle of room at breathing line.
10.26,	Recess began. Doors left open about ten minutes. Fires quickened. Two to seven girls stayed in.
10.42,	Air sample taken in middle of room at breathing line.
10.48,	Scholars came in from recess.
11.05–15,	Air-meter measurements at outlets: indicated discharge, 59,280 cubic feet per hour.
11.33,	Air-meter measurements at outlets (two only): indicated discharge, about same as before.
11.45,	Air sample taken in middle of room at breathing line.
11.50,	School dismissed.

Contents of room, 10,740 cubic feet. Air space for each of 42 scholars, 256 cubic feet. Average age of scholars, 9 years, 3 months.

Chase Avenue Schoolhouse, Upper Room, March 31, 1887.

TIME.	Number of persons present.	Air temperature (Fahrenheit).	Humidity of air (percentage of complete saturation).	Carbonic acid in air (parts in 10,000).	Temperature out of doors.
8.45–48, ...	2	56	–	4.22	–
9.15, ...	37	68	–	–	33
9.30, ...	37	72	–	–	–
10.06, ...	37	67	26	–	34
10.10–15, ...	37	–	–	11.13	–
10.44–48, ...	1	65	–	5.22	–
11.00, ...	36	65	30	–	36
11.10–30, ...	36	–	–	–	–
11.42–45, ...	36	70	–	10.74	–

Clear day. Wind from north northwest, strong.
At Water Office, 8 A.M. — Barom., 29.93; D. B., 25.5; W. B., 22.5; Humid., .56.
" " 1 P.M. — Barom., 30.00; D. B., 39.0; W. B., 36.0; Humid., .73.

Chase Avenue Schoolhouse, Upper Room, March 31, 1887.

TIME.	
8.40, . .	Platform outlets all open, except one nearest to chimney. Upper outlets closed. Inlets all closed, on account of the cold! (Mercury at 54°.) One fire burning, — on northwest side. Quickened fire, and opened northwest inlet.
8.50, . .	Scholars came in.
9.00, . .	Went down cellar, and found chimney stove red-hot, and door into chimney wide open! Closed door.
9.30, . .	Temperature, 72°. Opened southeast inlet.
10.25, . .	Recess began. Scholars all went out. Teacher opened two front windows on southeast side, from the bottom, about two feet each.
10.35, . .	Windows closed.
10.50, . .	Recess ended.
11.05, . .	Teacher opened doors into entries.
11.10, . .	One door closed, leaving the other open into a closed entry.
11.47, . .	School dismissed.

Contents of room, 10,170 cubic feet. Air space for each of 36 scholars, 282 cubic feet. Average age of scholars, 10 years, 8 months.

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